THE UNIVERSITY OF ALBERTA

CORPORATE ORGANIZATION AND THE SPATIAL MARKETING OF FLOUR IN CANADA

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Corporate Organization and the Spatial Marketing of Flour in Canada submitted by Patrick Guthrie Cadden in partial fulfilment of the requirements for the degree of Master of Arts.

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ABSTRACT

This work attempts to identify, within a specific study context, effects of industrial corporate organization on commodity flow patterns. The activity studied is the Canadian flour milling industry, and attention is focused on the significance of multi-plant milling firm organization to the explanation of flour distribution patterns. A description is presented of the general geographic character of flows of wheat to flour mills and of flows of flour to markets, and a number of ways outlined in which the multi-mill firm may differ from the single mill firm in terms of contribution to the overall pattern of flour movements. An application of linear programming is then made to the problem of deriving least cost flour shipment patterns for selected mill locations in western Canada. Solutions are obtained for two different conditions of corporate mill ownership. In the first instance, the assumption is made that all the mills are under single plant firm ownership, while in the second it is assumed that actual ownership conditions prevail. All the mills selected are owned by multi-mill firms, and the optimal flow patterns for each of the companies are summed to permit comparison with the optimal shipment pattern derived for the hypothetical situation of independently owned mills. Conclusions are then drawn as to the apparent

utility of continuing research into the spatial ramifications of corporate organization.

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CHAPTER I

INTRODUCTION

A dimension of industrial organization which has been frequently neglected in explanatory studies of industrial locations and commodity flows is the spatial structure of the multi-plant firm. Either by choice or through circumstance, it has often been the practice of industrial geographers to analyze spatial distributions almost wholly in terms of a recognized set of location factors, and to minimize investigation of the corporate ownership of manufacturing facilities. This practice has, in turn, been reflective of empirical inattention to the possible spatial significance of inter-firm competition under conditions not incorporated into theories of industrial and retail location. Theoretical solutions have been mainly derived for single plant firms employing f.o.b. plant pricing systems, and for firms in which basing-point pricing is practised. In an age when the conglomerate, the multi-plant firm and the multinational corporation dominate industrial activity, and basing-point pricing is either illegal or liable to governmental investigation, existing theories may lose part of their relevance. There is a need for more information on the manner in which large corporations organize space.

The present work is a geographic investigation of selected aspects of the corporate organization of the Canadian flour milling industry. The objectives of the analysis are twofold: (i) to describe the principal locational forces influencing the spatial form of wheat and flour shipments in Canada, and (ii) to compare least cost flows of flour derived under different assumptions of corporate ownership for a selected group of mills in western Canada.

Shipments of wheat and flour are the results of the spatial separation of material, mill and market locations, but, in explanation of shipment patterns, consideration must be taken of the fact that a number of mills are owned by multi-mill firms. Each of the mills owned by a multi-mill firm plays an alloted role in the national marketing strategy of the firm, and it often happens that the distance from a mill to a market centre is greater than the equivalent distance from the mill of a competitor. In a macro analysis, flows from the more distant mill would be difficult to explain if no account was taken of the existing organizational factors, and a rationale exists for the consideration of these factors by geographers.

The second study objective is operationalized through the use of linear programming. This technique has been applied to the derivation of optimal shipment patterns in a variety of industries but production locations have usually been selected without regard to the corporate ownership of

the plants at those points. As a consequence, the probability of implementation of the optimal industrial solutions may be low, given the problem of obtaining co-operation between competing entrepreneurs in their marketing activities. In the present instance, optimal shipment patterns are derived for each of the three multi-plant milling firms in western Canada, for a given moment in time. The flows in the three solutions are then summed, and a comparison made with the solution derived for a hypothetical situation in which all the mills of the milti-plant firms are under independent ownership, and each firm does not compete for custom in every available market. If differences are found to exist, they may be indicative of the role of the multi-mill firm as an organizer of space, given that the single-mill firm situation is a norm.

The drawing of more definite conclusions is precluded by certain limitations to the analysis. All the production and consumption data used are estimated from published gross statistics, and only multi-mill firm mill locations have been included. In the absence of actual sales data, the share of each multi-mill firm in each market has been assumed to be constant, and no allowance has been made for spatial variation in market shares resulting from such factors as consumer brand preference and income elasticity of demand. It is assumed throughout that the objective of all milling enterprises is to minimize costs, rather than to

maximize profits, and, in the summation of the least cost flows of the multi-mill firms, no consideration has been taken of competitive interdependency between oligopolists. It would have been preferable to compare the optimal solution for n single-mill firms with the actual flow pattern, which is the aggregate expression of the interplay of all relevant factors, rather than with the summation of multi-mill optima derived only with respect to wheat prices and flour shipment cost. Adequate information on actual flows was not, however, obtained.

The comparison of patterns is specifically undertaken to test the hypothesis that there are distinct differences between a least cost shipment pattern derived for a group of single mill producers and the pattern obtained through the summation of the least cost patterns of the individual multi-mill companies.

CHAPTER II

THE LOCATIONS OF MATERIALS, MILLS AND MARKETS

Commodity flows occur to link together material sources, manufacturing plants and markets. In the Canadian flour milling industry, grain and a number of minor materials are assembled at mills and the products of the milling operation distributed to areas of demand, both domestic and foreign. The underlying spatial form of wheat and flour shipments will be discussed in terms of the locations of areas of wheat cultivation, mills and markets, and, the effects of transportation costs.

Material Inputs to Flour Milling

The physical process of wheat flour milling involves the grinding of wheat grain into flour, and, into a number of joint products classified collectively as millfeeds. The extraction rate of flour from the wheat input averages seventy-two percent[1], but sales of flour account for about eighty-five percent of the total value of mill shipments.[2] The selling price of flour is higher than the highest priced grade of Hard Red Spring Wheat (Table 2-1) and flour consequently has a greater value per unit weight than wheat. By

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1 Wheat Flour Institute, From Wheat to Flour. Chicago, 1966, p. 44.

2 Average percentage for the years 1966-1968. Calculated from data in: Canada. Dominion Bureau of Statistics. Flour Mills. Cat. No. 32-215. The Queen's Printer, Ottawa, 1966, Table 13, p.8; 1967, Table 8, p.8; 1968, Table 6, p.6.

contrast, the price of the millfeeds produced is lower than the price for the equivalent weight of wheat, but apparent loss in value associated with production of millfeeds is more than proportionately offset by the difference in value between wheat and flour.

The principal material inputs in addition to wheat are bleach, chemical nutrients (thiamine, niacin, riboflavin and iron), and packing materials, while other variable cost items are fuel, electricity and labour. Of the total cost of variable inputs of Canadian flour mills, wheat is estimated to

TABLE 2-1 : COMPARATIVE PRICES OF FLOUR, WHEAT AND MILLFEEDS

(Dollars per hundredweight)

COMMODITY	AVERAGE MONTHLY PRICE AT WINNIPEG, 1966-1968
Hard Red Spring Wheat (Domestic sales price at Thunder Bay less statutory railway rate from Winnipeg):	
No. 1 Manitoba Northern	3.22
Feed Wheat[a]	2.87
Flour (Fancy patents, carlots, f.o.b. destination)	7.75
Millfeeds (Shorts, 100 lb. sacks, carlots, f.o.b. milldoor, Winnipeg)	2.82

[a]Feed wheat is the lowest priced grade of Hard Red Spring Wheat

Source: Canada. Dominion Bureau of Statistics. Quarterly Bulletin of Agricultural Statistics. Cat. No. 21-003. The Queen's Printer, Ottawa, tables entitled "Mid-Month Prices of Flour, Bran, Shorts and Middlings at Principal Markets," and "Canadian Wheat Board Monthly Average Cash Prices per Bushel of Wheat, Basis in Store Fort William-Port Arthur," in issues for January-March 1966 to October-December 1968, inclusive.

account for about four-fifths, on the basis of published figures which show the cost division in all flour mills, including those which grind other grains (Table 2-2).

TABLE 2-2 AVERAGE ANNUAL CONTRIBUTION OF PRODUCTION FACTORS TO TOTAL COST OF MANUFACTURING ACTIVITY IN CANADIAN FLOUR MILLS, BY PRODUCTION FACTOR, 1966-1968

(Percentages)

PRODUCTION FACTOR	PERCENTAGE CONTRIBUTION TO TOTAL COST
Total materials and supplies	93.2
Wheat	80.8
All ingredients	86.6
Containers and packaging materials	5.4
Other materials and supplies	1.2
Wages	6.0
Fuel and electricity	0.8
TOTAL COST OF MANUFACTURING ACTIVITY	100.0

Source: Canada. Dominion Bureau of Statistics. Flour Mills. Cat. No. 32-215. The Queen's Printer, Ottawa, 1966, Table 1, p. 1, and Table 12, pp. 7-8; 1967, Table 1, p.2, and Table 7, pp. 7-8; 1968, Table 1, p.2, and Table 5, pp. 5-6.

All other materials account for only 12.4 percent of the total cost of manufacturing activity, and wheat is, for all intents and purposes, the only material input of major cost significance. Furthermore, there is little spatial variation in relative expenditure on variable cost items (Table 2-3), suggesting that there may be limited scope for factor substitution.

TABLE 2-3 AVERAGE ANNUAL CONTRIBUTION OF PRODUCTION FACTORS TO TOTAL COST OF MANUFACTURING ACTIVITY IN CANADIAN FLOUR MILLS, BY PRODUCTION FACTOR AND BY PROVINCE, 1966-1968

(Percentages)

PROVINCE	THE FACTOR COST AS PERCENTAGE OF TOTAL COST			
	Materials & supplies	Wages	Fuel and elect'y.	Total cost of mfg. activity
Quebec	93.9	5.5	0.6	100.0
Ontario	93.6	5.6	0.8	100.0
Manitoba	92.4	6.8	0.8	100.0
Saskatchewan	92.1	6.8	1.1	100.0
Alberta	92.9	6.3	0.8	100.0
CANADA	93.2	6.0	0.8	100.0

Source: Canada. D. B. of S. Flour Mills. Catalogue No. 32-215. The Queen's Printer, Ottawa, 1966, Table 1, p. 1; 1967, Table 1, p. 2; 1968, Table 1,p.2.

Note: No mills were in operation in Newfoundland, the Yukon Territory and the Northwest Territories. Data on mill operations in Prince Edward Island, Nova Scotia and British Columbia not published due to secrecy requirements of the Statistics Act. Percentage values for Manitoba based on 1967 data only, due to secrecy requirements of the Statistics Act preventing publication of 1966 and 1968 data.

The chief areas of wheat cultivation are the prairies and southern Ontario, but the classes of wheat grown in each area are different (Table 2-4). The cultivation of Hard Red Spring Wheat, which is ground to hard wheat flour (bread flour), is virtually confined to the Prairie Provinces, as is the cultivation of Durum Wheat, the source of flour used in the production of macaroni. Soft White Winter Wheat, which is milled to cake, biscuit and pastry flour, is grown primar-

TABLE 2-4 - WHEAT ACREAGE IN CANADA, BY CLASS AND BY PROVINCE: NOVEMBER ESTIMATES, 1964-1968

CLASS OF WHEAT AND PROVINCE	1964		1965		1966		1967		1968	
	Acres x 10^3	Per-cent	Acres x 10^3	Per-cent	Acres x 10^3	Per-cent	Acres x 10^3	Per-cent	Acres x 10^3	Per-cent
HARD SPRING WHEAT										
Manitoba	3265.0	12.0	3200.0	11.8	3212.0	11.3	3458.0	12.2	3270.0	12.3
Saskatchewan	17659.0	64.6	17775.0	65.6	18500.0	65.4	18540.0	65.2	17000.0	63.7
Alberta	6268.0	22.9	5975.0	22.1	6390.0	22.6	6270.0	22.1	6220.0	23.3
PRAIRIE PROVINCES	27192.0	99.5	26950.0	99.5	28102.0	99.3	28268.0	99.5	26490.0	99.3
Atlantic Provinces	7.9	0.0	11.0	0.0	7.5	0.0	7.7	0.0	8.5	0.0
Quebec	10.9	0.0	12.2	0.1	29.0	0.1	29.1	0.1	30.0	0.1
Ontario	17.0	0.1	14.0	0.1	22.0	0.1	13.0	0.1	11.0	0.0
British Columbia	115.0	0.4	93.0	0.3	127.0	0.5	101.0	0.3	158.0	0.6
CANADA	27342.8	100.0	27080.2	100.0	28287.5	100.0	28418.8	100.0	26697.5.	100.0
SOFT WINTER WHEAT										
Ontario	455.0	(a)	362.0	(a)	363.0	(a)	400.0	(a)	355.0	(a)
DURUM WHEAT										
Manitoba	120.0	6.4	40.0	4.8	43.0	4.0	62.0	4.8	130.0	5.5
Saskatchewan	1541.0	81.6	725.0	86.3	905.0	85.1	1130.0	86.8	2000.0	84.4
Alberta	227.0	12.0	75.0	8.9	116.0	10.9	110.0	8.4	240.0	10.1
CANADA	1888.0	100.0	840.0	100.0	1064.0	100.0	1302.0	100.0	2370.0	100.0

Source: Canada. Dominion Bureau of Statistics. Quarterly Bulletin of Agricultural Statistics. Catalogue No. 21-003. October-December issues for 1965-1969 inclusive.

(a) Ontario acreage accounts for almost 100 per cent of Canadian acreage, but there are also "relatively small quantities of winter wheat" cultivated in the Prairie Provinces (Ibid., October-December 1969, p. 236).

ily, although not exclusively, in southern Ontario.

Markets for Mill Products

Hard wheat flour accounts for four-fifths of the total flour shipments from Canadian flour mills (Table 2-5),

TABLE 2-5 : AVERAGE ANNUAL MILL SHIPMENTS OF WHEAT FLOUR, BY FLOUR TYPE AS PROPORTION OF TOTAL SHIPMENTS, 1966-1968

(Percentages)

FLOUR TYPE	PERCENTAGE PROPORTION OF TOTAL WHEAT FLOUR SHIPMENTS
Hard Wheat Flour[a]	80.1
Soft Wheat Flour[b]	7.8
Durum Flour and Semolina	5.0
Other Edible Wheat Flour[c]	7.1

[a]The sum of the following grades of flour: Spring No. 1 or Top Patent; Spring No. 2 Patent; Spring No. 3 Patent; and, Whole Wheat and Graham Flour.

[b]Ontario Winter Wheat Flour.

[c]Various grades of hard and soft wheat flour.

Source: Canada. Dominion Bureau of Statistics. Flour Mills. Cat. No. 32-215. The Queen's Printer, Ottawa, 1966, Table 13, p.8; 1967, Table 8, p.8; 1968, Table 6, p.6.

and accounts for most of the sales of Canadian flour in both domestic and export markets. However, domestic flour consumption data are lacking. Spatial variations in flour consumption are not readily identifiable as there are no data published for provincial or sub-provincial areal units, and studies have not been made of the income elasticity of demand

for flour in Canada. Markwalder[3] reports that elasticity studies undertaken in the United States in the 1950's revealed a negative income elasticity of demand for flour, a positive income elasticity of demand for bakery products, and a negative income elasticity of demand for flour consumed in all forms. In the absence of substantive evidence, it is difficult to speculate on the likelihood of similar patterns of consumer behavior in Canada. Even at the national level, the only published consumption statistic is a residual termed "apparent per capita domestic disappearance",[4] which is calculable from specially constructed commodity balance sheets. The published figure includes quantities of flour used in industrial processes, and takes no account of inventory held in warehouses, bakeries and retail outlets,[5] so is best interpreted as a surrogate for human consumption. Subject to this qualification, provincial consumption can be estimated on the basis of apparent per capita domestic disappearance, and, provincial population, assuming that the spatial pattern of consumption approximates the spatial distribution of population. Thus, the four western

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3 D. A. Markwalder, "The Flour Milling Industry: an Economic Study of Excess Capacity". The Northwestern Miller, Vol. 265, July 24, 1961, pp. 31-32.

4 Canada. Dominion Bureau of Statistics. Apparent Per Capita Domestic Disappearance of Food in Canada. Cat. No. 32-226. The Queen's Printer, Ottawa, annual.

5 "Flour Consumption in Canada". The Northwestern Miller, Vol. 281, Jan. 1971, p. 17.

provinces together account for twenty-seven percent of national consumption of wheat flour, while Ontario, Quebec and the Atlantic Provinces consume seventy-three percent.[6]

Export markets for flour which are of importance to Canada are primarily the United Kingdom, the United States, central America, the Caribbean, and parts of Africa and Asia.[7] Exports accounted for an average 46.0 percent of the flour shipped from Canadian mills in the period 1950-1959, but have since declined to approximately one-third[8] because of a fall in the absolute level of exports (Fig. 1) related to more competitive trading conditions, and the construction of new mills in developing countries in Africa, Asia and South America. The latter have chosen to import grain rather than flour in order to make use of the millfeeds produced in the milling operation while at the same time providing domestic employment.[9]

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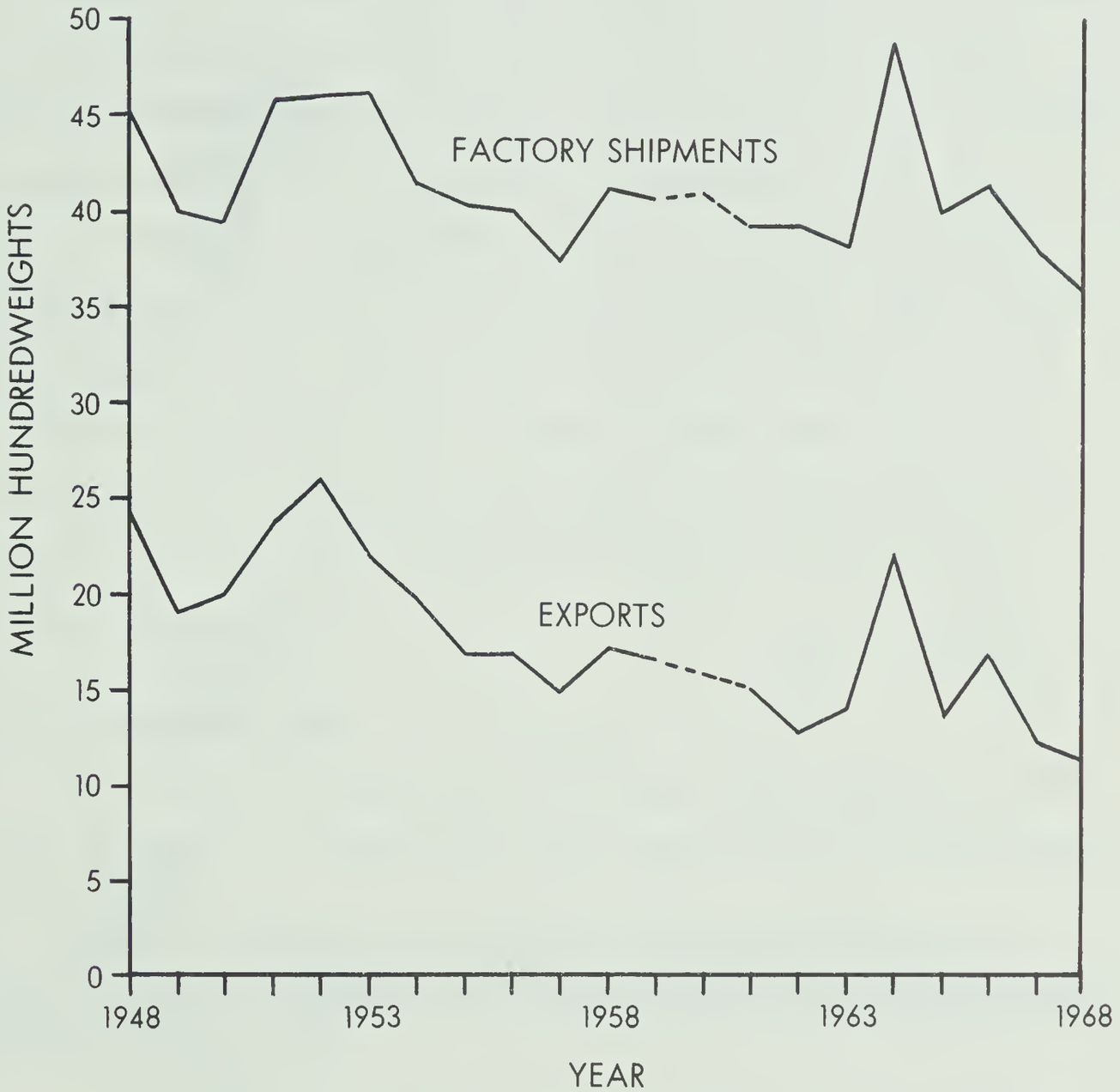
6 Canada. Dominion Bureau of Statistics. Estimated Population of Canada by Province at June 1, 1970. Cat. No. 91-201. The Queen's Printer, Ottawa, 1970, p.2.

7 This conclusion was reached after analysis of data in: Canada. Dominion Bureau of Statistics. Trade of Canada, Vol. Two: Exports. Cat. No. 65-202. The Queen's Printer, Ottawa, annual issues for 1946-1958 inclusive; biennial issues for 1959-60 to 1965-66 inclusive; and triennial issue for 1966-68.

8 Calculated from data in the above source, and from data in: Canada. Dominion Bureau of Statistics. The Flour and Feed Milling Industries. Cat. No. 32-215. The Queen's Printer, Ottawa, annual issues for 1950-52 inclusive; Idem, The Flour Milling Industry. Cat. No. 32-215. The Queen's Printer, Ottawa, annual issues for 1953-59 inclusive; Idem, Flour Mills, Cat. No. 32-215, The Queen's Printer, Ottawa, annual issues for 1960-68 inclusive.

9 G. Yakulic, "Flour Milling Prosperity in Peril", Western Business and Industry, Vol. 38, Nov. 1964, p. 28.

FIGURE 1
FACTORY SHIPMENTS AND EXPORTS OF CANADIAN WHEAT FLOUR, 1948-1968



Source: Canada. Dominion Bureau of Statistics. *Flour Mills,* Catalogue No. 32-215, and, *Trade of Canada Volume II, Exports,* Catalogue No. 65-202, 1948-1968

1948-1959 values: basis 1948 Standard Industrial Classification

1960 values: basis Revised Standard Industrial Classification

1961-1968 values: basis Revised Standard Industrial Classification and New Establishment Concept

Markets for millfeeds are less easy to identify. These joint products must compete with standard feed grains in livestock feed markets, and due to this availability of close substitutes, they are price elastic and are sold at a competitively determined price wherever there is a demand. It can be assumed that the spatial form of the domestic market approximates the spatial distribution of the Canadian livestock population, but while the prairie region is surplus in feedgrain production, eastern Canada and British Columbia are deficit.[10] It may be, therefore, that a more than proportionate share of the millfeeds market is to be found in the latter areas. Export markets are relatively unimportant, the proportion of total millfeeds production exported in the period 1964-1968 averaging only fifteen percent annually.[11]

Flour Mill Locations

The spatial distribution of wheat flour mills in 1967 (Fig. 2) tends to approximate the distribution of population

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10 Canada. Agricultural Economics Research Council of Canada. The Benefits and Burdens of Feedgrain Transportation Policy, by M. L. Lerohl, G. A. MacEachern and H. Vandermeulen. Ottawa, 1970, p. 12.

11 This figure was calculated from data in: Canada. Dominion Bureau of Statistics. Flour Mills. Cat. No. 32-215. The Queen's Printer, Ottawa, annual issues for 1964-1968 inclusive; Idem, Trade of Canada, Volume Two: Exports. Cat. No. 65-202. The Queen's Printer, Ottawa, biennial issues for 1963-64 and 1965-66, and triennial issue for 1966-68.

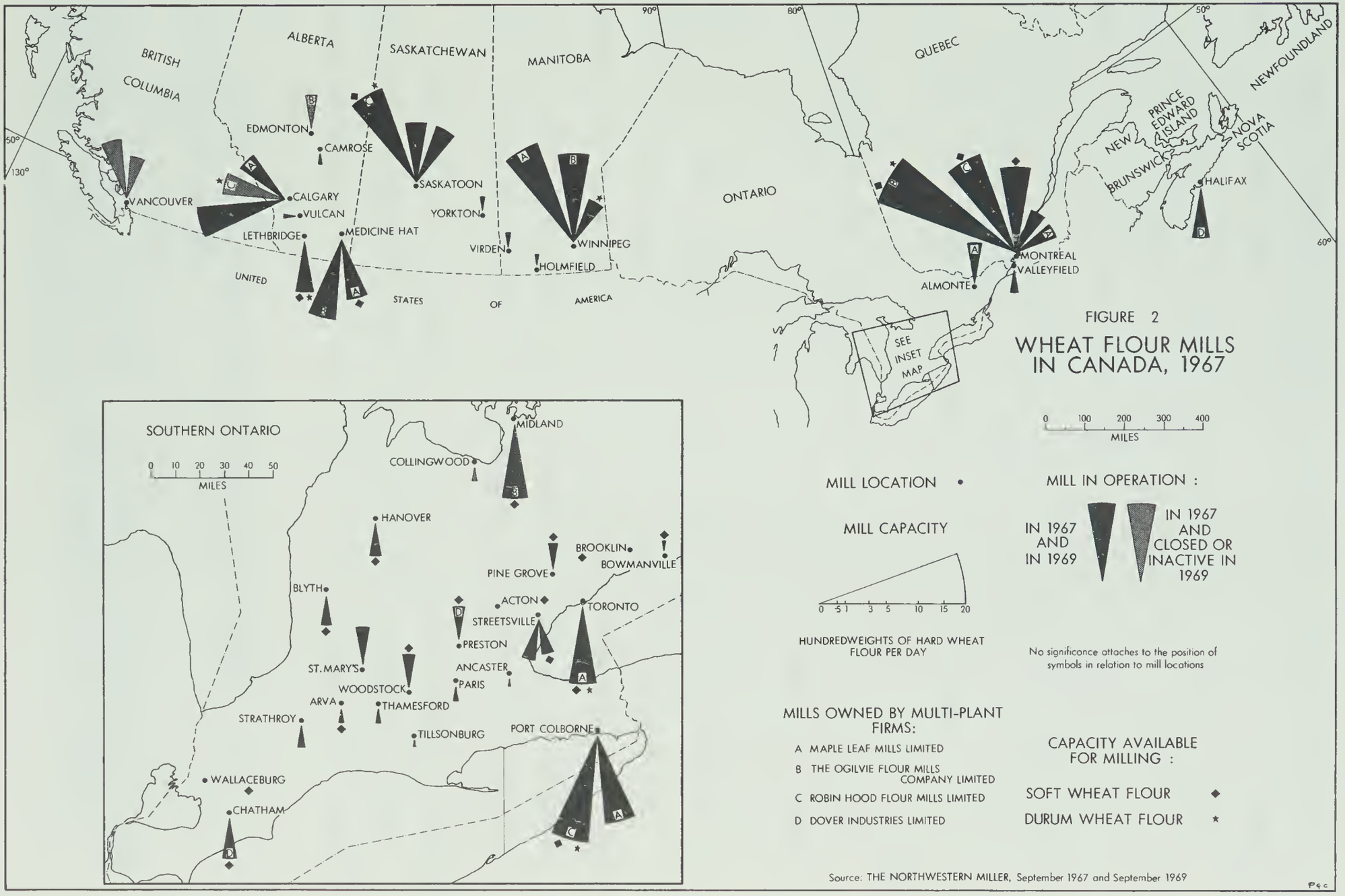

FIGURE 2

WHEAT FLOUR MILLS IN CANADA, 1967

MILL LOCATION •

MILL CAPACITY

0 5 1 3 5 10 15 20

HUNDREDWEIGHTS OF HARD WHEAT FLOUR PER DAY

MILL IN OPERATION :

IN 1967 AND IN 1969

IN 1967 AND CLOSED OR INACTIVE IN 1969

No significonce attaches to the position of symbols in relation to mill locations

MILLS OWNED BY MULTI-PLANT FIRMS:

A MAPLE LEAF MILLS LIMITED

B THE OGILVIE FLOUR MILLS COMPANY LIMITED

C ROBIN HOOD FLOUR MILLS LIMITED

D DOVER INDUSTRIES LIMITED

CAPACITY AVAILABLE FOR MILLING :

SOFT WHEAT FLOUR ◆

DURUM WHEAT FLOUR ★

Source: THE NORTHWESTERN MILLER, September 1967 and September 1969

and major population centres in Canada. Sixty percent of the fifty-two mills in operation were in Ontario and Quebec, while Manitoba and Alberta accounted for a further thirty percent. In terms of available mill capacity, Ontario and Quebec mills accounted for only fifty-three percent of the national total, reflecting the relatively small capacities of many Ontario mills. The mills in Manitoba and Alberta accounted for thirty-two percent, an approximately proportional share of total capacity.[12] Market-orientation of mills is suggested, but material-orientation is also reflected. Prairie mills are located at the source of their principal material input, as are soft wheat flour mills in southern Ontario. Both material sources, and, size and location of markets would have been essential considerations in the initial choice of mill locations but it is beyond the scope of this study to speculate on the total complex of unique and non-unique factors considered in past decision making.

Similarly, no attempt is made to detail reasons for mill closures, of which there were sixty-one in western Canada and sixty-eight in eastern Canada in the period 1946-1968.[13]

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12 These percentages were calculated from data in: "List of Flour Mills in the United States and Canada." The Northwestern Miller, Vol. 274, September 1967, pp. 75-80.

13 These figures were calculated from data in: Canada. Dominion Bureau of Statistics. Report on the Flour and Feed Milling Industry in Canada. 1946, 1947; The Flour and Feed Milling Industry. 1948-1952; The Flour Milling Industry. 1953-1959; Flour Mills. 1960-1968. Catalogue No. 32-215. The Queen's Printer, Ottawa.

As a general statement, it is likely that a broad underlying cause was the increased competition made possible by improvements in transportation. Many mills were established in times when communications were poor and when it was essential for communities to have their own local mills, or, at least to have easy access to a mill. When it became possible for more distantly located mills to compete for custom in the markets previously reserved to community mills, many of the latter were forced out of business.

Transportation Cost Factors

Transport costs possess a limited potential for affecting the form of wheat and flour flows. Freight costs are an unavoidable expenditure, and because most of the movement of these commodities is by rail, and railway freight rates on grain and grain products are normally the same, there is no freight cost advantage to be gained from maximizing the distance of rail movement of one commodity in preference to the other. Millers have not, therefore, had to be tied to highly material-oriented or market-oriented locations on account of railway freight rate differentials. For this reason, the railway freight rate arrangement known as "milling-in-transit" has not been as significant a locational force as it might have been under other circumstances. Under the terms of this arrangement, a miller who uses the railway to ship grain from country elevator to mill, and grain products (into which category flour falls) from mill to subsequent destin-

ation, can obtain a discounted rate for the overall movement. He is charged the through rate for grain from country elevator to final destination, rather than the sum of an inbound charge and an outbound charge. This sum would include two sets of terminal charges, and the in-transit privilege permits avoidance of one set by the shipper. An additional handling charge is levied for delivery to and from the mill (five cents per hundredweight in 1967), but notwithstanding, the total outlay involved is still less than the sum of an inbound rate and a separate outbound rate.

The modes used in the shipment of wheat and flour are naturally determined by the lowest rate available for a particular commodity movement, although speed of delivery is sometimes important. Some mills maintain small fleets of trucks for short-range deliveries of flour, but within western Canada and eastern Canada, the bulk of the movement of wheat and flour is by common carrier railways, and, to a lesser extent, trucking firms. Within these two areas,choice of mode has little effect on the route of wheat or flour shipment between any pair of locations as major road and railway routes are found in relatively close proximity in most populated areas of southern Canada. By contrast, modal choice can affect the shipment route when commodities are to be moved from western Canada to eastern Canada. Steamship companies provide common carrier service on the Great Lakes and offer lower rates on both wheat and flour than railway and trucking firms hauling goods by land routes around the Lakes.

Further, the lake freight rate on wheat is lower than on flour, as a partial consequence of the movement of grain in bulk and the movement of flour in bags.[14] Thus, if eastern Canada has to obtain wheat or flour from the prairies, transport costs will be minimized by the shipping of prairie wheat to the Lakehead (Thunder Bay) under low statutory railway rates ("Crow's Nest Pass Rates") for subsequent shipment in lake freighters to eastern destinations. The resulting shipment route would differ from that associated with the surface carriage of wheat in the Great Lakes area, although the origins and destinations of the flows would be the same.

A further reason for the shipment of wheat in preference to flour is winter cessation of navigation on the Great Lakes. In order to ensure that eastern Canadian hard wheat flour demands can be met in the winter season, three courses of action appear possible: (i) the accumulation of wheat in eastern mill elevators during the navigation season, for subsequent milling during the freeze-over period; (ii) the accumulation of prairie-milled flour in eastern warehouses during the navigation season, for storage and distribution during the freeze-over period; or (iii), the rail shipment of wheat or flour from western Canada, for immediate milling or distribution during the freeze-over period. As the latter

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[14] Pers. comm. W. Hussen, Area Sales Manager, Canada Steamship Lines, Edmonton, Alberta, April 29, 1971.

course is the most expensive to implement due to railway freight rates being higher than lake freight rates, the basic choice is between storage of wheat or flour. In practice, it appears more economical to store wheat, which is less prone to deterioration than flour, and to utilize milling capacity on a year round basis. The alternative would be to incur the costs of allowing capacity to lie idle for a season and of maintaining warehouse space only fully used in the winter.

The freight rate element of transportation costs would, therefore, appear to be of limited significance in affecting the shipment routes of wheat and flour, and the length of haul of one commodity in relation to the other. Transhipment cost, on the other hand, may have directly influenced the choice of certain mill sites and consequently affected the flows of wheat and flour in a local area. For example, four large mills in southern Ontario have lakeside sites, which permit avoidance of the transhipment costs incurred in the unloading of grain from lake freighters into boxcars or trucks for movement to mills with inland locations. These lakeside mills are located in, or close to, areas of high population density, so it is likely that market considerations were of equal or greater importance than transhipment cost avoidance in the choice of mill location.

Flows of Wheat

Given the existing locations of wheat cultivation, mills and flour markets, and the limited spatial effects of trans-

port costs, the general patterns of wheat and flour shipments are discussed. Protein content is the criterion adopted by mills in their selection of grain, although actual purchases have to be made on the basis of wheat grades established by the Canadian Wheat Board. Customer requirements vary with regard to flour protein content, and a mill must be flexible in its ability to produce a variety of flours. To be able to achieve this through blending, qualities of wheat of varying protein content are assembled and stored. Protein content cannot, however, be predetermined as it is a function of genetic factors, and variable environmental factors such as soil type, rainfall, sunshine and temperature.[15] Year to year variation in wheat protein values within any given area is marked,[16] thereby eliminating the possibility of precisely delimiting a permanent wheat supply area for a flour mill.

In any single year, prairie mills usually draw their wheat requirements from within a one hundred mile radius of the mill location, but assembly distance can vary up to as much as three hundred miles. The localities from which supplies of wheat of a particular protein content are drawn are decided by the results of tests on samples of wheat sent to the mills from country elevators. The wheat is then pur-

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15 Canada. Dept. of Agriculture, Board of Grain Commissioners for Canada. Protein Content of Canadian Wheat 1927-1968, by V. Martens and I. Hlynka. Winnipeg, 1969, p. 1.

16 Ibid., pp. 3-122.

chased from the Canadian Wheat Board and may be brought from a country elevator by truck or railway boxcar, or alternatively trucked in direct from a farm without first being delivered to a country elevator. In the latter instance, the milling company must be in possession of a mill elevator licence to conform with the conditions of the Canada Grain Act[17], and the farmer must have selected the mill as his grain delivery point. Delivery may only be made when quota delivery is authorized at the point by the Canadian Wheat Board and as a result of the erratic and unpredictable frequency of authorization, a mill cannot reliably obtain a large part of its supply requirement by this method. Inbound shipments from country elevators consequently provide the bulk of the wheat needs of prairie mills as shipments may be made at any time. Once a country elevator bin is emptied, however, further shipments of the same grade of wheat from the same elevator are only possible after the Wheat Board has authorized further quota delivery by farmers to the elevator point.

When there were operative flour mills in British Columbia, wheat requirements would have been shipped from country elevators in the western prairies. At present, only flour mills in eastern Canada ship out wheat from the prairies for domestic flour milling purposes. Soft wheat grown in Ontario is unsuitable for baking of bread and manufac-

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17 Canada. Department of Agriculture, Board of Grain Commissioners for Canada. Grain Elevators in Canada for Crop Year 1969-70 As at August 1, 1969. The Queen's Printer, Ottawa, 1969, pp. 1, 206, 207.

ture of macaroni, and supplies of hard and durum wheat must consequently be obtained from western Canada. The origins of the flows are determined by Winnipeg-based agents for the eastern mills, again on the basis of wheat protein content. Purchases of wheat are mostly made from country elevators in the eastern prairies, from which haulage by rail occurs to Thunder Bay, for transhipment into lake freighters. The wheat is conveyed to ports in southern Ontario, where it is unloaded into railway boxcars for haulage to mills, or directly unloaded into a lakeside mill elevator.

Flows of soft wheat to flour mills are short, and low in volume. Soft wheat flour is milled in only three western mills, and their needs are met from the contract growing of White Spring Wheat in irrigated areas near the border with the United States. The purchase procedure is the same as for other classes of wheat. Eastern soft wheat flour mills grind Ontario Winter Wheat, the prices for which are set by a provincial marketing board.

Flows of Flour

The localities to which flour mills ship their products are probably decided by such economic factors as transport costs, price competitiveness with other milling firms in winning short and long term orders, administrative linkages with bakeries, and the degree of competition and overall profitability of supplying particular retail markets. In the case of the multi-mill firm mill, an additional factor is the

national marketing strategy of the owner firm, the possible spatial significance of which is discussed in Chapter Three. The result of the interplay of determining factors is that the domestic market areas of western mills are mainly found within British Columbia, the Prairie Provinces and northern Ontario, while the eastern Canadian market is primarily supplied by mills in southern Ontario, southern Quebec and Nova Scotia. In addition, many western and eastern mills compete for export orders, but, due to reasons of distance cost, Asian markets are the only overseas markets which it may be more economic to serve from western rather than eastern mills. Due to the marked contraction in Asian markets, the flow of exports from western Canadian mills has been reduced, and most of the present day flows to major foreign customers originate in Ontario and Quebec, although exports from eastern mills have also fallen.

The patterns of supply of durum wheat flour and soft wheat flour are similar to those for hard wheat flour. Western Canadian purchasers of durum wheat flour are supplied by western mills, while eastern customers are supplied with flour ground from prairie-grown durum wheat in eastern Canadian mills. Likewise, most of the soft wheat demands of the western bakery trade are met from the milling of locally grown soft wheat, but so too are the demands of eastern customers. The necessity of importing prairie-grown soft wheat is precluded by the local cultivation of Ontario Winter Wheat.

Indeed, eastern Canada is a net interregional exporter of soft wheat flour, as higher value added convenience foods in which soft wheat flour is a principal ingredient, household cake mixes for example, are distributed to western Canada from centralized production units in the east.

The underlying pattern of wheat and flour flows in Canada has been described through reference to the locations of origins and destinations, and to the effects of transport costs on the choice of commodity moved. At a less generalized level, this ideal pattern of flows can be distorted by the activities of multi-mill firms in various ways outlined in the following chapter.

CHAPTER III

CORPORATE ORGANIZATION AND CANADIAN FLOUR SHIPMENT PATTERNS

A number of flows of flour can only be fully explained when analysis is undertaken into the corporate organization of the Canadian flour milling industry. To date, surprisingly few studies by economic geographers have included analyses of the firm as a determinant of economic activity,[1] but the manner in which an enterprise is structurally organized directly affects the shipment and linkage patterns of the industry of which the firm is a member. Krumme[2] reports that researchers are displaying a growing interest in the behaviorial aspects of location decision-making by firms, but little account appears to have been taken of the significance of plant location in the overall marketing strategy of the multi-plant firm, or, indeed, of marketing strategies in general. In a flow chart in the same paper,[3] "processes of spatial behavior of firms" are divided into two discrete groups: "production oriented decision-making" and "spatial market policies", but, while the former is subjected to subsequent disaggregation, the latter is not. Steed similarly omits discussion of marketing policies from two papers re-

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1 G. Krumme,:"Toward a Geography of Enterprise". Economic Geography, Vol. 45, 1969, p. 30.

2 Ibid., pp. 30-40.

3 Ibid., p. 37.

lating to the geographic implications of corporate organization[4] but does explicitly recognize that decisions are made by multi-plant firms regarding the distribution of production lines between plants, the expansion and contraction of production in different plants, and, the desirability of intercorporate merger.[5] The choices made in each case would have a direct bearing on commodity flow patterns.

Multi-mill Flour Milling Firms in Canada

The Canadian flour milling industry is dominated by three multi-mill firms. In 1967, 65.5 percent of total rated capacity of Canadian flour mills was installed in the seventeen mills owned by these firms. The remaining capacity was distributed among thirty-five other mills, of which thirty-two were owned by single mill companies.[6] It is believed that all but two or three of the latter companies restricted their domestic marketing activities to areas within either western or eastern Canada. The three major multi-mill companies, on the other hand, all supplied their products on a nationwide basis, and the spatial sig-

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4 G. P. F. Steed, "Corporate Enterprise and the Location Decision Process", in W.R.D. Sewell and H.D. Foster (eds.), The Geographer and Society. Western Geographical Series, Vol.1. University of Victoria Dept. of Geography, Victoris, 1970, pp. 160-171; Idem, "Locational Implications of Corporate Organization of Industry". The Canadian Geographer, Vol. 15, 1971, pp. 54-57.

5 Idem, "Corporate Enterprise", p. 162.

6 Calculated from data in: "List of Flour Mills in the United States and Canada". The Northwestern Miller, Vol. 274, Sept. 1967, pp. 75-80.

nificance of corporate organization to flour shipment patterns is to be found primarily in the manner in which flour is distributed to markets by multi-mill firms.

Market Areas of the Multi-mill Firms

The milling points from which the three major multi-mill firms supplied the needs of their domestic and export markets in 1967 are indicated in Fig. 2. Company A shipped from seven points, Company B from five points, and Company C from four points, but by 1969, the number of mills owned by Companies B and C had each been reduced by one. As a result of the different numbers and locations of mills owned by each of the companies, the networks of service areas of the three firms were dissimilar in both size and shape. A body of theory exists to explain how market areas may be divided between competing producers in the absence of collusion, but a number of factors limit the relevance of this theory to the case at hand. In the seminal work by Hotelling,[7] a cluster solution was derived for the problem of where competing merchants would locate in order to obtain maximum advantage in serving consumers uniformly distributed along a line. This solution was subsequently rejec-

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7 H. Hotelling, "Stability in Competition". The Economic Journal, Vol. 39, 1929, pp. 41-57.

ted or modified by a number of other authors,[8] but reviews of their contributions[9] indicate that, in all instances, the assumption was made that prices charged to customers were f.o.b. plant. Similarly, in all the solutions each producer had a spatial monopoly of the market area immediately surrounding his derived plant location. These conditions are invalid in the context of the Canadian flour milling industry because prices to customers are set on zonal delivered bases, and because there is competition between milling firms within most localities.

Every multi-mill firm has assigned a spatial service area to each of its mills, and as there is no spatial competition among mills owned by the same firm, a further reason is provided for deeming inappropriate the conceptual frameworks of Hotelling and the "locational interdependence" school. More relevant theory, which has sought

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8 F. A. Fetter, "The Economic Law of Market Areas." Quarterly Journal of Economics, Vol. 38, 1923-24, pp.520-529; A. P. Lerner and H. W. Singer, "Some Notes on Duopoly and Spatial Competition." Journal of Political Economy, Vol. 45, 1937, pp. 145-186; A. Smithies, "Optimum Location in Spatial Competition." Ibid., Vol. 49, 1941, pp. 423-439; E. H. Chamberlin, The Theory of Monopolistic Competition. Eighth edition, Harvard University Press, Cambridge, Mass., 1965, pp. 260-265. More recent contributions not reviewed in the works listed in footnotes seven and eight are: B. H. Stevens, "An Application of Game Theory to a Problem in Location Strategy." Papers and Proceedings of the Regional Science Association, Vol. 7, 1961, pp. 143-157; N. E. Devletoglou, "A Dissenting View of Duopoly and Spatial Competition." Economica, Vol. 8, 1968, pp. 135-148.

9 M. L. Greenhut, Plant Location in Theory and in Practise. The Univ. of North Carolina Press, Chapel Hill, N. Carolina, 1956, pp.23-42 and 140-156; W. Isard, Location and Space-Economy. The Technology Press of M. I. T. and John Wiley and Sons, Inc, New York, 1956, pp. 158-171.

to delimit the market areas of manufacturing or retailing establishments whose locations are fixed, is to be found in works by Hoover, Isard and Alonso.[10] These authors show that the market area of a manufacturing plant encloses the customers to whom transportation costs from the plant are lower than from other plant locations, and this would appear to have been the objective of each of the major Canadian multi-plant flour milling firms in the assignment of market areas to their mills. The consequence for the macro pattern of flour shipments is that there can be a variety of mill locations from which supplies are delivered to particular markets. For example, flour is supplied to the Lower Mainland of British Columbia by Company A from Calgary, by Company B from Medicine Hat, and by Company C from Saskatoon, and perhaps also by independent mills in Alberta and Saskatchewan. In an industry entirely composed of single plant firms, it might be expected, for reasons of transport cost, that the nearest mill location would supply the needs of any given market, assuming the availability of necessary mill capacity. The fact that it is the policy of the three multi-mill firms to supply all areas in Canada results in the occurence of flows which it might be difficult to explain if the owners of mills at particular locations were not identified.

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10 E. M. Hoover, The Location of Economic Activity. McGraw-Hill Book Company, Inc., New York, 1948, pp. 50-53; W. Isard, op.cit., pp. 143-158; W. Alonso, "Location Theory", in J. Friedman and W. Alonso (eds.), Regional Development and Planning, M.I.T. Press, Cambridge, Mass., 1964, pp. 94-98.

Flows of Flour for Export

Export orders obtained by both multi-plant and single plant flour milling firms are the result of competitive tendering between firms, or, in the case of sales arranged at government level, the allocation of orders among companies by the Canadian National Millers Assocaition. By definition, the origins of shipments of flour to export points by single mill firms are spatially predetermined, but internal production policies may affect the origins of flows of export flour milled by the multi-mill firms. It is the policy of at least one multi-mill firm "...to spread...all milling production amongst [its] mills in order to give them as much operating capacity as possible...."[11] Further, it is probable that all the multi-mill firms distribute their export production to some degree. The manner of distribution will depend on the destination and size of each order, and the capacity available in each of the mills at the time that an order is placed.

Nationality of owner firm is another aspect of corporate organization which influences the shipment patterns of export flour. There is an embargo by the United States on trade with Cuba, and this prohibition applies to American-owned companies in Canada. As one multi-mill firm and several single mill firms are affected, they cannot supply an important overseas buyer of Canadian flour. All other things being equal, Canadian-owned mills ship a greater than expected amount to Cuba.

[11] Pers. comm. V. S. McNaughton, Plant Manager, Maple Leaf Mills Ltd., Calgary, Alberta, July 22, 1971.

Intra-corporate Rationalization

Company rationalization schemes have a distinct effect on the form of flour shipment patterns. The long-term alternatives open to a single mill firm which is experiencing prolonged economic difficulties are reduction of installed capacity, or closure and withdrawal from the flour milling industry. By contrast, the closure of a mill by a multi-mill firm will only result in a greater concentration of milling capacity within the firm, and does not necessarily mean that the mill products of the firm will cease to be available in the area where the mill was closed. One multi-mill firm, for example, closed mills at Moose Jaw (1966) and Calgary (1969) and now supplies all of western Canada, including the area previously supplied by the closed mills, from a mill at Saskatoon. Thus, marked dislocations of pre-existing outbound flows of flour occurred, but the fixed locations of the other mills owned by the company predetermined the character of the adjustment in shipment patterns. In the case of a closure of a mill owned by a single plant firm, only random prediction would be possible of the impact on the form of shipment patterns of competitors. Customers of the newly defunct mill would have to transfer their allegiance to other companies' products, and the unique response would determine the new shipment patterns from other mills.

Competitive Advantages of the Multi-mill Firm

In the spatial marketing of flour, the multi-mill firm has an important competitive advantage over the single plant firm as a result of the dispersion of the mills owned by the former type of corporate organization. Flour is produced for both national and export markets at three or more spatially separated mills owned by the company and, all other things being equal, the average total cost of flour shipment incurred by the multi-mill firm in supplying all its domestic customers is less than the average cost would be to an independently owned company nationally distributing flour from a single mill location.

Similarly, the dispersion of multi-mill firm mills allows the multi-mill firm to offer competitive tenders for overseas export orders irrespective of the seaboard from which navigation will commence. The single mill firm would only seem able to actively compete for overseas orders from ports adjacent to the region in which the mill is located. Unless there is a substantially lower cost of production than in mills located close to the more distant seaboard, or a willingness to accept a narrower profit margin than might be acceptable to competitors, the independent mill would appear to be at a competitive disadvantage in serving the more distant seaboard and distant domestic markets, on account of transport costs.

The role of the independent mill is frequently restricted to the filling of such export orders as may be obtained, and of small orders placed by local bakeries. Exceptions to this rule are provided when vertical organizational arrangements are in force. One independent mill at Saskatoon, for instance, supplies a food processing plant owned by the same company at Peterborough, Ontario, while another mill at Saskatoon distributes flour through the outlets of a part-owned retail subsidiary. However, multi-plant firms have vertically integrated further through the acquisition of bakery chains and the establishment of organizational or contractual links with other major bakeries, food processors and retailers. In addition, the multi-plant firm obtains an important sales advantage from its very size and financial resources; it can afford to maintain arnationwide sales force with representatives in all major market centres, while the independent firm, with its smaller financial resources, cannot.

Recognition has been given to several ways in which corporate organization, and in particular the multi-mill firm, can affect the form of flour shipment patterns in Canada, and more intensive analysis might reveal other ways in which corporate organization could contribute to explanation of observed flow. The findings described are unlikely

to be obtained from an analysis of location made without reference to the form and identity of ownership of individual flour mills, and, in a wider context, there is a case for the investigation of the linkage patterns associated with multi-plant firms in other industries. Distinction between universal and unique effects on the form of commodity shipment patterns would then be assisted.

CHAPTER IV

LINEAR PROGRAMMING IN STUDIES OF SPATIAL FORM

The second objective of this study, to generate least cost shipment patterns for flour from selected mills in western Canada, was achieved through use of linear programming. This iterative algebraic facilitates

> "the analysis of problems in which a linear function of a number of variables is to be maximized (or minimized) when those variables are subject to a number of restraints in the form of linear inequalities."[1]

Of the several types of problem which the procedure is capable of solving, the transportation problem is the most relevant to use in geographic analysis. It assumes that a given commodity is produced at a number of places (sources) and consumed at a number of other places (sinks). The total demand at each point of consumption, and the total supply at each point of production, are known, and the problem is to determine how much each producing point should ship to each consuming point so that all sink demands are satisfied, all source supplies are shipped to sinks, and the total costs of transportation are minimized.

Applications by Geographers and Agricultural Economists

Workers in the fields of geography, economics and operations research have made applications of linear programming,

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[1] R. Dorfman, P.A. Samuelson and R. M. Solow, Linear Programming and Economic Analysis. McGraw-Hill Book Company, Inc., New York, 1958, p. 8.

but within geography as whole, there has been relatively little interest displayed in the utilization of the technique. Early recognition of the potential of linear programming was given by a geographer in 1959,[2] but since that time only a few applications have been reported in the geographic literature. Solutions which have been obtained have related to transportation problems as diverse as the delimitation of school districts[3] and public utility service areas,[4] the analysis of variations between observed and optimal movements of people to physicians,[5] and the derivation of least cost shipment patterns for interregional trade in aluminum bar,[6] wood, and lumber.[7] A greater number of

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2 W. L. Garrison, "Spatial Structure of the Economy: II", Annals, Association of American Geographers, Vol. 49, 1959, pp. 471-482.

3 M. Yeates, "Hinterland Delimitation: a Distance Minimizing Approach". The Professional Geographer, Vol. 15, 1963, pp. 7-10.

4 K. R. Cox, "The Application of Linear Programming to Geographic Problems". Tijdschrift voor Economische en Sociale Geografie, Vol 56, 1965, pp. 231-234.

5 R. L. Morrill, "The Movement of Persons and the Transportation Problem", in W. L. Garrison and D. F. Marble(eds), Quantitative Geography Part 1: Economic and Cultural Topics. Northwestern University Studies in Geography No. 13. Northwestern University, Evanston, Illinois, 1967, pp. 84-93.

6 Cox, op. cit., pp. 234-235.

7 B. M. Barr, The Soviet Wood Processing Industry: A Linear Programming Analysis of the Role of Transportation Costs in Locations and Flow Patterns. University of Toronto Dept. of Geography Research Pub. No. 5. Univ. of Toronto Press, Toronto, 1970, 135 pp.

interregional trade analyses have been made by agricultural economists, who have derived minimum cost assembly, processing and distribution patterns for a number of agricultural commodities including cattle and meat,[8] processed tomato products,[9] pears,[10] and vegetables.[11]

Interregional Shipment Analyses of Grain and Flour

Relatively few examples are to be found of derivations of optimal interregional shipment patterns for grain and flour, whether using actual or hypothetical data. One of the earlier studies was by two geographers, Morrill and Garrison,[12] who sought to derive the pattern of interregional trade in wheat and flour in the United States. In addition

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8 F. E. Aylor and M. E. Juillerat, Least-Cost Movement Analysis of Slaughter Cattle and Calves with Emphasis on the Southeast, Southern Cooperative Series, Bulletin No. 133, Alabama Agricultural Experiment Station, Auburn, Ala., 1968, 127 pp; G. A. King and S. H. Logan, "Optimal Location, Number and Size of Processing Plants with Raw Product and Final Product Shipments". Journal of Farm Economics, Vol. 46, 1964, pp. 94-108.

9 A. R. Koch and M. M. Snodgrass, "Linear Programming Applied to Location and Product Flow Determination in the Tomato Processing Industry". Papers and Proceedings of the Regional Science Association, Vol. 5, 1959, pp. 151-162.

10 J. F. Stollsteimer, "A Working Model for Plant Numbers and Locations". Journal of Farm Economics, Vol. 45, 1963, pp. 631-645.

11 L. Polopolus, "Optimum Plant Numbers and Locations for Product Processing". Journal of Farm Economics, Vol. 47, 1965, pp. 287-295.

12 R. L. Morrill and W. L. Garrison, "Projections of Interregional Patters of Trade in Wheat and Flour". Economic Geography, Vol. 36, 1960, pp. 116-126.

to obtaining a solution on the basis of estimates of actual regional surpluses and deficits, predictions were attempted of the probable effects of (a) drought and (b) spatial population change on the initially generated pattern. The original regional surplus and deficit values were adjusted, and solutions were obtained using these new input data. However, the whole country was divided into only five different regions, and the information derived was consequently of a general spatial nature. The value of the contribution lies in its provision of examples of hypothetical geographical problems to which linear programming may be applied.

More recently, Wright[13] achieved substantially the same initial objective in his application of the transhipment model, a multi-stage elaboration of the transportation problem. Input data related to seventy-one supply areas and fifty-seven consuming regions, and the results were presented in aggregated form for eight different regions. Account was taken of movement of export wheat to ports, and a forecast made of the effect on the general locational pattern of flour mills of a reduction in freight rates for wheat. By contrast, Leath and Martin[14] presented a hypothetical expository formulation of the transhipment problem

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13 United States. Department of Agriculture Economic Research Service. Regional and Sectoral Analysis of the Wheat-Flour Economy: A Transportation Study by B. H. Wright. Marketing Research Report No. 858, Wash. D.C., 1969, 46 pp.

14 M. N. Leath and J. E. Martin, "The Transhipment Problem with Inequality Restraints". Journal of Farm Economics, Vol. 48, 1966, pp. 894-908.

in relation to wheat and flour, and Maxfield[15] derived least cost solutions for the movement of American export wheat from growing areas to ports. In the Canadian context, Walker[16] applied linear programming to the transportation problem of shipping feedgrains from Thunder Bay to destinations in eastern Canada, and compared optimal with actual flow patterns. Craddock[17] also used the technique to determine

> "...the pattern and location of cereal crop production [in] Canada that would minimize the combined production and transportation costs for the nation, as a whole, in meeting specified levels of annual cereal demand."[18]

Limitations of Previous Applications

The works cited above show that there has been a widely held conviction as to the utility of the linear programming technique. However, the results obtained have not necessarily been directly capable of implementation in the real world. The optimal derivations have implicitly assumed origins to be under independent ownership. In reality, one owner may control the output of a number of origins. Thus,

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15 D. W. Maxfield, "An Interpretation of the Primal and Dual Solutions of Linear Programming." The Professional Geographer, Vol. 21, 1969, pp. 255-263.

16 Canada. Agricultural Economics Research Council of Canada. The Transportation of Feed Grains in Eastern Canada, by H. V. Walker. Publication No. 8. Ottawa, 1967, 85 pp.

17 Canada. Economic Council of Canada. Interregional Competition in Canadian Cereal Production, by W. J. Craddock. Special Study No. 12. Ottawa, 1970, 257 pp.

18 Ibid., p. 5.

while deviations of the actual pattern from the generated pattern may be interpreted as irrational or indicative of competitive inefficiency, the pattern which exists may be the summation of patterns optimal to individual multi-plant producers. Realistically, the operationalization of many of the solutions obtained to date would be restricted to two specific contexts. The first would be where all origins were under the control of a single decision-making authority with an established objective of cost minimization as distinct from profit maximization. The second would be where all origins were independently owned, a situation which is becoming less common in the context of industrial manufacturing establishments. The researcher must, therefore, choose at the outset whether to limit his interest to the activity of a single corporate organization, or, to set an academic objective free of real world operational constraints. The latter course permits analysis to be made of the whole rather than just a part of the whole, but, too frequently, applications of linear programming in spatial contexts are vague in specifying whether or not the derived solutions are intended to be put into effect. The present study seeks to investigate the differences that may exist between optimal solutions to the problem of flour distribution in western Canada which have been derived under different assumed conditions of corporate organization. In the first, the mills included are assumed to be owned by independent

single mill firms, while in the second, each mill is owned by one of three multi-mill firms. The solutions for each of the three multi-mill firms are then summed and compared with the solution derived for the n producer situation.

CHAPTER V

LEAST COST FLOUR SHIPMENT PATTERNS IN WESTERN CANADA

Four optimal sets of flows were obtained for the shipment of hard wheat flour from multi-mill firm mills to markets in 1967. In Problem One, a least cost shipment pattern was generated under the assumption of total independence of mill ownership. In reality, the mills included were owned by three multi-mill firms and in Problems Two, Three and Four, least cost flows were generated from the mills owned by each of the three individual producers. The individual producer optima were then summed, and the resultant configuration compared with the form of the solution to the first problem. Comparison was also undertaken of the dual solutions to each problem.

Sources and Sinks

The study area consisted of the four western provinces and northwestern Ontario. The mills operated by the three national multi-plant companies were selected as sources, and eleven aggregations of contiguous Census Divisions were delineated as markets (Fig. 3). The quantity of hard wheat flour available for shipment from each mill was calculated by multiplying published daily plant capacity[1] by the number

[1] "List of Flour Mills in the United States and Canada". The Northwestern Miller, Vol. 274, Sept. 1967, pp. 75-80.

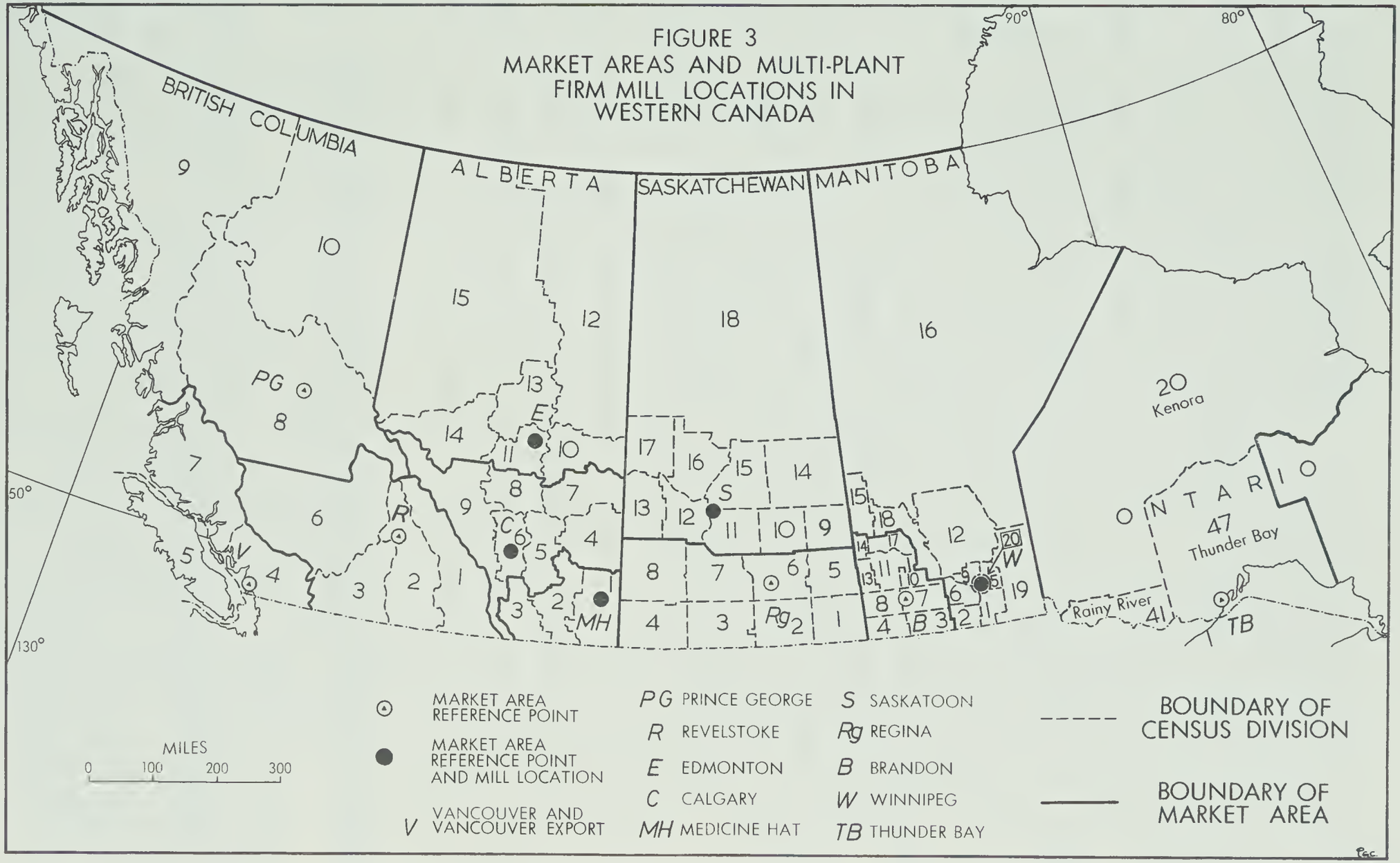
FIGURE 3
MARKET AREAS AND MULTI-PLANT
FIRM MILL LOCATIONS IN
WESTERN CANADA
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
90°
80°
50°
130°
PG
R
E
C
V
S
Rg
B
W
MH
TB
20
Kenora
47
Thunder Bay
Rainy River
41
MILES
0 100 200 300
MARKET AREA REFERENCE POINT
MARKET AREA REFERENCE POINT AND MILL LOCATION
V VANCOUVER AND VANCOUVER EXPORT
PG PRINCE GEORGE
R REVELSTOKE
E EDMONTON
C CALGARY
MH MEDICINE HAT
S SASKATOON
Rg REGINA
B BRANDON
W WINNIPEG
TB THUNDER BAY
BOUNDARY OF CENSUS DIVISION
BOUNDARY OF MARKET AREA

of working days in 1967 (250). The point-destination requirement of the transportation problem was met through the selection of a large or strategically located urban settlement within each of the market areas. Domestic consumption within each area was then derived from the multiplication of the estimated total population within the area[2] by a per capita consumption figure, calculated as shown in the Appendix. Account was also taken of demands for prairie milled flour in eastern Canada, the United States, and overseas countries. Demands at Thunder Bay and Winnipeg were inflated in accordance with published freight movement and export data[3] but special allowance had to be made for exports moved through Vancouver. Statutory railway rates ("Crow's Nest Pass Rates") apply on the latter movements, and as these rates are lower than those on flour destined for domestic consumption at Vancouver, a separate destination, "Vancouver Export", was introduced, increasing the total number of sinks to twelve. By contrast, all flour

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2 Canada. Dominion Bureau of Statistics. Population Estimates for Counties and Census Divisions 1967. Cat. No. 91-206. The Queen's Printer, Ottawa, Table 6, pp. 26-31.

3 Canada. Dominion Bureau of Statistics. Railway Freight Traffic, Year Ended December 31, 1967. Cat. No. 52-205. The Queen's Printer, Ottawa, Table 15, p. 88; Idem, Shipping Report, Part Two: International Seaborne Shipping (By Port), 1967. Cat. No. 54-203. The Queen's Printer, Ottawa, Table 6, pp. 34, 39-48; Idem, Shipping Report, Part Three: Coastwise Shipping 1967. Cat. No. 54-204. The Queen's Printer, Ottawa, Table 11, pp. 56, 63; Idem, Trade of Canada, Vol. Two; Exports, Calendar Years 1966-68. Cat. No. 65-202. The Queen's Printer, Ottawa, Table 3, p. 86; Idem, Trade of Canada; Exports by Mode of Transport 1967. Cat. No. 65-206. The Queen's Printer, Ottawa, Table 5, pp. 171-172.

moved to Thunder Bay by rail is hauled under statutory eastbound rates, irrespective of destination east of Thunder Bay. A second export sink was not, therefore, required.

The three companies under study accounted for 61.4% of the total daily hard wheat flour milling capacity in western Canada in 1967. This percentage was used as a surrogate for the share of total sales in every market area held by the independent mills in total and by the three multi-mill firms in total. The percentage share of total capacity owned by each multi-mill company was then necessarily assumed to be roughly equivalent to its share of sales in both domestic and export markets: 23.1 percent in the case of Company A, 20.4 percent in the case of Company B, and 17.9 percent in the case of Company C.

The Cost Matrix

The cell values in the cost matrix (Table 5-1) were summations of the average 1967 mill price of No. 1 Northern wheat set by the Canadian Wheat Board[4] and, railway freight rates in effect on July 1, 1967.[5] The official procedure for calculating the selling price of wheat to a miller was employed in deriving a price at each of the mills. This

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4 Canada. Dominion Bureau of Statistics. Grain Trade of Canada. Cat. No. 22-201. The Queen's Printer, Ottawa, 1966-67, Table 70, p. 71; 1967-68, Table 58, p. 65.

5 Canadian National Railways. Tariff Nos. W. 184-D and W. 950, with supplements in effect July 1, 1967; Canadian Pacific Railway. Tariff Nos. W. 819-A and W. 849-B, with supplements in effect July 1, 1967; Canadian Trasnport Commission. Tariff Nos. (AC) 1589, 1762, 1765, 1774 and 2234, with supplements in effect July 1, 1967.

procedure was to deduct the statutory railway rate on export grain from the country elevator of origin to Vancouver or Thunder Bay, from a price set "basis in store" at the terminal to which the export rate was lower. The Vancouver price was used for all the mill locations except Winnipeg, and in the absence of information concerning the exact locations of the country elevators from where the mills drew their supplies, allowance was made for the difference in locations by the arbitrary addition of one cent to the export rate used in each mill price calculation.

In-plant costs were not available. Information obtained from mill managers and the statement by Bain that plant-scale economies are "...quite unimportant in flour milling...."[5] suggest that production costs per unit of volume would not have varied markedly among the mills included in the set of Problems.

The Transportation Problem

The input data having been assembled, a computer programme prepared by the Department of Computing Science, University of Alberta, was used to obtain optimal solutions to the four transportation problems with the standard algebraic form:

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5 J. S. Bain, Barriers to New Competition: Their Character and Consequences in Manufacturing Industries. Harvard University Press, Cambridge, Mass., 1962, p. 229.

$$\text{Minimize } C = \sum_{i=1}^{M} \sum_{j=1}^{N} X_{ij} C_{ij} \qquad (1)$$

$$\text{subject to } \sum_{j=1}^{M} X_{ij} = a_i \qquad (2)$$

$$\sum_{i=1}^{N} X_{ij} = b_j \qquad (3)$$

$$\sum_{i=1}^{N} a_i = \sum_{j=1}^{M} b_j \qquad (4)$$

$$X_{ij} \geq 0 \qquad (5)$$

where C is the total combined cost of purchase of wheat at i mill locations and shipment of flour from i mill locations to j deficit regions

X_{ij} is the amount of flour shipped from the i^{th} mill location to the j^{th} deficit region

a_i is the amount of flour available for interregional shipment from the i^{th} mill location

b_j is the amount of flour required by the j^{th} deficit region

C_{ij} is the combined cost per hundredweight of purchase of wheat at the i^{th} mill location and the shipment of flour from the i^{th} mill location to the j^{th} deficit region

For any linear programming minimization problem, there is a dual maximizing problem. In the present set of problems, the optimal solution to each primal problem minimizes the total combined costs of wheat purchase at i mill locations and flour shipment from i mill locations to j deficit regions. The optimal solution to each dual problem assigns a value u_i to every mill location and a value v_j to every deficit region. Following the interpretation by Cox[6], these values represent mill prices and delivered prices, respectively, the quantity which is maximized being the total excess of delivered values over mill values. For each shipment route entering into the optimal minimization solution, the difference between the values of u and v is the corresponding shipment cost. If the u_i values in the dual solution to each problem are then scaled, with the highest value being set equal to zero, a measure is obtained of the relative advantage accruing to each mill location as a consequence of the structure of the cost matrix. A positive scaled u value thus represents the difference in cents per hundredweight between the f.o.b. price that must be charged at that mill location if output is to be disposed of without loss, and the f.o.b. price at the mill location with the greatest locational advantage. The v_j values, on the other hand, measure the delivered prices that correspond to the most economic allocation of output

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6 Cox, op. cit., p. 231.

from the viewpoint of minimum aggregate transportation cost. Comparison of v values therefore permits assessment of the relative locational advantage of deficit regions in terms of the price to be paid per hundredweight of flour.

Both the primal and dual solutions to the present set of problems are given, but while the least cost flows derived for Problems Two, Three and Four are subsequently summed, the corresponding sets of dual values are not added together. This is because dual values relate to costs per hundredweight and are interpreted primarily as relative values.

Problem One: Assumptions and Optimal Solutions

Problem One related to the hypothetical situation in which all the mills of the three companies were considered as being under independent ownership. In order that the demand for flour in each market would equal the total demand for flour produced by the three multi-mill firms, the estimated total demand in each area was prorated to the the level of 61.4 percent. The assumptions were then made that: (i) the share of each mill in each market was not predetermined; (ii) each mill gave priority to serving the market area in which it was located, and did so at zero transport cost; and (iii), there was inter-company agreement to equalize the percentage level of excess capacity among all mills. Assumption (ii) was operationalized by deduction of *in situ* consumption from the set of initial surpluses and deficits,

while assumption (iii) necessitated the scaling down of the surplus available for interregional shipment at each mill location. Total surpluses exceeded total deficits, and the surplus available at each location was reduced by 32.0 percent in order that the percentage level of excess capacity at each mill would be equalized, and total surpluses equal total deficits, a basic requriement of the transportation problem. A shipment matrix of four origins and eight destinations was then constructed, the quantities supplied and demanded at these locations being as shown in Tables 5-2 and 5-3. The optimal solution to the primal problem (Solution One) is shown in matrix form in Table 5-4, and diagrammatically in Figure 4. In the main, market areas are supplied from adjacent mill locations, but the statutory railway rates allow Vancouver Export and Thunder Bay to draw their requirements from further afield. The dual values, which are given in Table 5-10, show that the most advantageously located milling point is Medicine Hat while the derived delivered prices indicate that Vancouver Export and Thunder Bay are the deficit points at which prices are lowest.

Problems Two, Three and Four : Assumptions and Optimal Solutions

Optimal shipment patterns were then generated for each of the three multi-mill companies whose mill location and capacity data were used in Problem One. Assumptions (i)

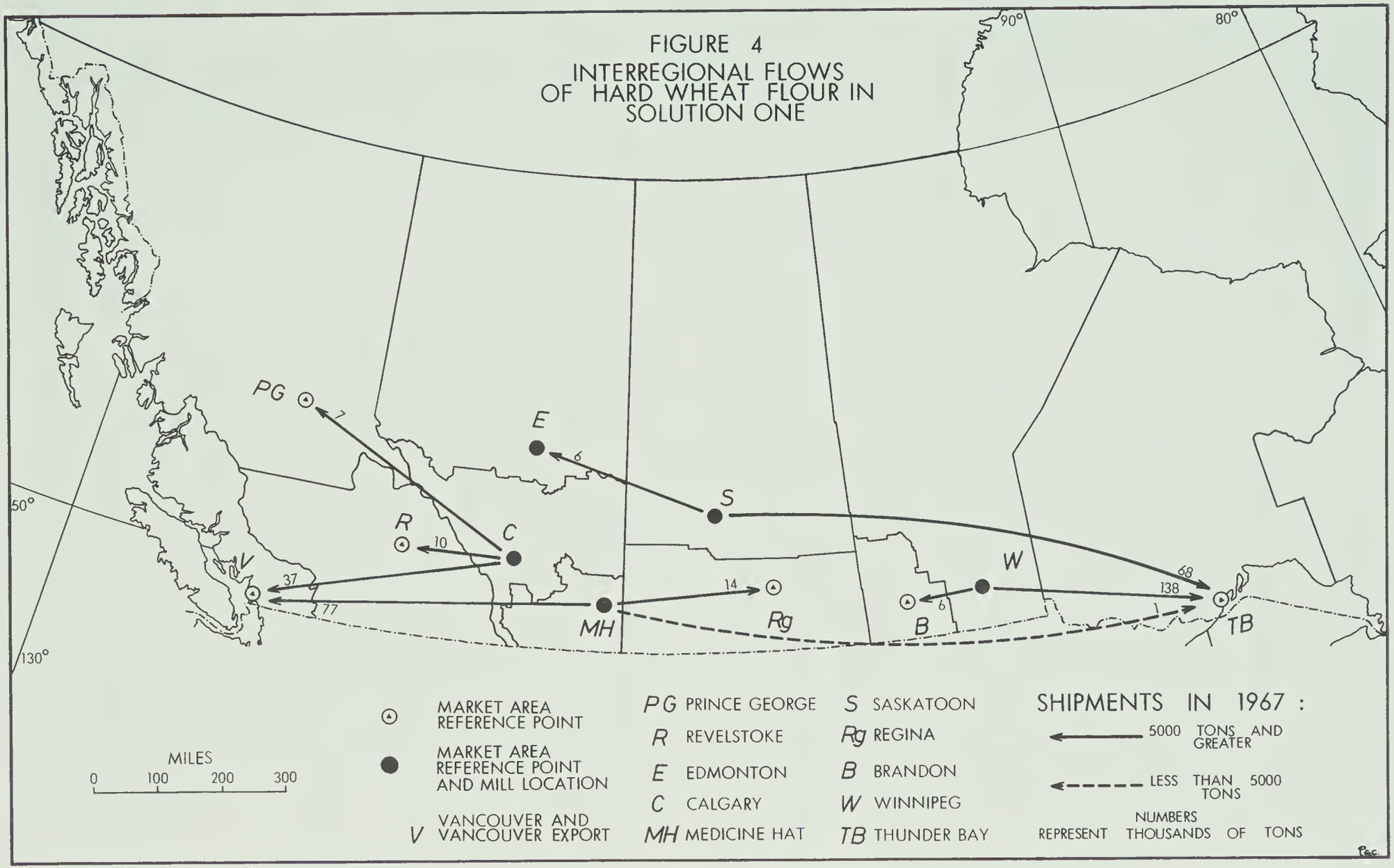
FIGURE 4
INTERREGIONAL FLOWS
OF HARD WHEAT FLOUR IN
SOLUTION ONE
90°
80°
50°
130°
PG
E
S
R
C
V
W
MH
Rg
B
TB
7
6
10
37
77
14
6
68
138
1
MILES
0 100 200 300
MARKET AREA REFERENCE POINT
MARKET AREA REFERENCE POINT AND MILL LOCATION
V VANCOUVER AND VANCOUVER EXPORT
PG PRINCE GEORGE
R REVELSTOKE
E EDMONTON
C CALGARY
MH MEDICINE HAT
S SASKATOON
Rg REGINA
B BRANDON
W WINNIPEG
TB THUNDER BAY
SHIPMENTS IN 1967 :
5000 TONS AND GREATER
LESS THAN 5000 TONS
NUMBERS REPRESENT THOUSANDS OF TONS

and (iii) of Problem One held in each instance, but the share of each company in each market was fixed prior to solution of each problem. Thus, market area demands were calculated by prorating the total consumption in each area to the level of the "market share" percentage of the company in question, and output reduced in accordance with assumptions (ii) and (iii) (Tables 5-5 and 5-6). In the case of assumption (iii), the factors by which surpluses were reduced were respectively 29.9 percent, 30.5 percent and 29.3 percent. The individual primal solutions obtained (Solutions Two, Three and Four) are shown in Tables 5-7, 5-8 and 5-9, and also display an assignment of market areas to adjacent mill locations, subject to the effects of the statutory export rates.

The corresponding dual values (Table 5-10) show that the relative locational advantage of any given mill location may vary among the dual solutions to the shipment problems in which the location appears. This variation might be expected as in each problem the same market areas are being supplied from different combinations of mill locations and at a different cost. Similarly, the equilibrium delivered prices vary between solutions, but in all cases, Prince George customers have to pay more per hundredweight of flour than customers at any other location, irrespective of the brand of flour that is purchased. Conversely, delivered prices are least in each instance at

either Thunder Bay or Vancouver Export.

Comparison of Solutions One and Five

The primal solutions to Problems Two, Three and Four were summed to give "Solution Five", which is shown in matrix form in Table 5-11 and diagrammatically in Figure 5. Comparison was then made of the value of the objective function (the minimized total combined cost of wheat purchase and flour shipment) in Solution One, and, the sum of the values of the objective functions in Solutions Two, Three and Four. It was found that the summed value, $28,110,888, was $2,744,483 or 10.8 percent in excess of the minimum cost that would be incurred in the situation of n independent producers. In specific terms, all market points with the exception of Prince George would be supplied at a total cost greater than the equivalent expenditure given in Solution One (Table 5-12). The lower cost of supplying demands at Prince George would be the result of no surplus being available for interregional shipment from Edmonton in Problem One. The assigned supply point in Solution One was Calgary, from where the freight rate was greater, whereas in Solution Five the needs of Prince George could be supplied from both Edmonton and Calgary. As a result, the cost of supplying Prince George was less in Solution Five than in Solution One.

The actual costs incurred by firms can only be equal to or greater than the corresponding optimal costs, and the

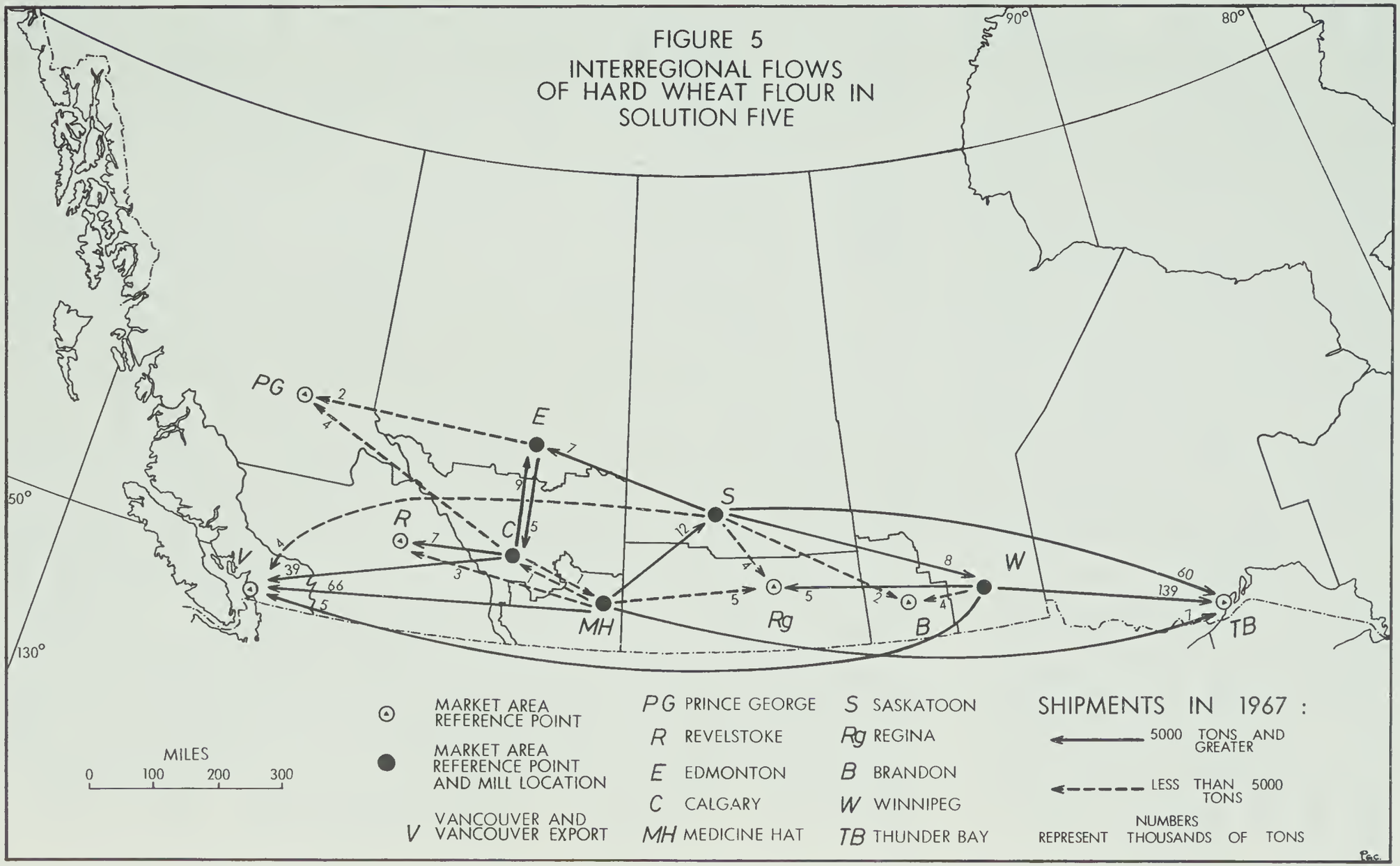
FIGURE 5
INTERREGIONAL FLOWS
OF HARD WHEAT FLOUR IN
SOLUTION FIVE
90°
80°
50°
130°
PG
E
S
R
C
V
MH
Rg
B
W
TB
2
4
7
9
5
12
4
7
8
60
139
39
66
5
3
1
1
5
5
2
4
7
MILES
0 100 200 300
MARKET AREA REFERENCE POINT
MARKET AREA REFERENCE POINT AND MILL LOCATION
V VANCOUVER AND VANCOUVER EXPORT
PG PRINCE GEORGE
R REVELSTOKE
E EDMONTON
C CALGARY
MH MEDICINE HAT
S SASKATOON
Rg REGINA
B BRANDON
W WINNIPEG
TB THUNDER BAY
SHIPMENTS IN 1967 :
5000 TONS AND GREATER
LESS THAN 5000 TONS
NUMBERS REPRESENT THOUSANDS OF TONS

percentage difference between the cost of Solution One and the cost of Solution Five is, therefore, a minimum. Actual data on company shipments were not available, but information received from company personnel indicated that the general form of each of the generated company patterns was correct. Thus, the actual percentage cost variation between the Solution One pattern and the Solution Five pattern is unlikely to be substantially greater than the calculated deviation, all other things being equal.

Distinct differences in flow pattern were associated with the cost variation. Pictorial evidence of these differences is given in Figures 4 and 5, which show that the pattern illustrating Solution One is less complex than that illustrating Solution Five. For example, there are ten discrete origin-destination links in the former pattern, whereas in the latter there are twenty-three. All mill locations originate more flow paths (Table 5-13) and all market points receive flour from at least as many mill locations in Solution Five as in Solution One (Table 5-14). Not unexpectedly, the percentage of total flour production which would be shipped interregionally would be nearly ten percent greater in Solution Five, and interregional shipments from individual mill locations would in all cases be greater, both relatively and absolutely (Table 5-15). Another difference is that, in Solution One, the market areas whose reference points coincided with mill locations were, with the exception of the Edmonton region, supplied entirely

in situ. In Solution Five, however, each company was allocated a certain share of every market, and unless all three firms had a mill at the location in question, there had to be inbound shipments of flour from other mill locations. On the other hand, total production in the study area remained the same in both situations due to the initial equalization of the total demand for flour milled by the three companies with the total demand for flour milled by the competing independent single mill companies.

Similar uniformity of variation was not apparent when a calculation was made at every mill location of a weighted average flow-line length (Table 5-16). In each instance the mileage to each destination was weighted by the tonnage moved, and a comparison made of the values in Solution Five with those in Solution One. At three of the five mill locations, values were greater in Solution Five, while at the remaining two, the reverse was true. For the mill locations as a group, the weighted average length of haul was approximately the same in both solutions. Thus, when consideration is also taken of the greater volume of interregional shipments in Solution Five, the summary statement can be made that a marginally greater amount of flour would be moved over a marginally shorter distance than would be the case in Solution One. However, interpretation of these values must be qualified. They are all expressions of relationships between selected point-locations and other selected point-

locations, and are hence unique. Different numerical values would have been obtained if other market area reference points had been chosen for the analysis, but the selected points include most of the largest population centres in western Canada, and the major flows of flour in the study area were measured.

Comparison of the dual values to Solution One with those corresponding to Solutions Two, Three and Four reveals that while it is valid to state that a mill location may have a particular level of locational advantage in an n producer situation (Solution One), it would be incorrect to automatically assume that the same relative locational advantage would accrue to a multi-mill firm mill at that location. Winnipeg, for example, has a low relative locational advantage in Solutions One and Three but a high relative locational advantage in Solution Two. Comparison of delivered prices in each of the solutions reveals that Prince George customers always pay the highest price for flour, whether it is produced by a single mill firm or any one of the multi-mill firms. At the opposite extreme, customers at Vancouver Export and Thunder Bay consistently pay less than most other customers. The relative levels of delivered prices at other markets vary between solutions and the most apparent similarity in variation is the consistently high level of prices paid by domestic destinations in British Columbia. It is further

noted that in all market areas at least one multi-mill producer can supply flour at a price lower than that specified in the solution to the independent producer problem.

Bearing in mind the limitations of the analysis which were listed in Chapter One, the basic hypothesis of this study is accepted. Comparison of values of parameters related to volume of interregional shipment, flow pattern geometry, and cost outlay have all revealed the existence of distinct dissimilarities. Because the total production in the single-mill firm situation equals the sum of the production of the three multi-mill firms, variations between Solutions One and Five may be explained by the differences in the assumed conditions of corporate organization.

TABLE 5-1 - COST MATRIX FOR THE TRANSPORTATION PROBLEMS

(Cents per hundredweight)

ORIGIN	DESTINATION					
	Vancouver	Vancouver Export	Prince George	Revelstoke	Edmonton	Calgary
Edmonton	377	348	381	389	---	352
Calgary	372	348	403	375	353	---
Medicine Hat	374	348	408	384	381	364
Saskatoon	385	348	406	401	350	356
Winnipeg	426	360	424	413	406	408

ORIGIN	DESTINATION					
	Medicine Hat	Saskatoon	Regina	Brandon	Winnipeg	Thunder Bay
Edmonton	368	356	390	403	408	354
Calgary	355	360	373	381	385	354
Medicine Hat	---	358	363	364	365	349
Saskatoon	385	---	363	380	360	346
Winnipeg	399	387	365	347	---	340

TABLE 5-2 - PROBLEM ONE: CALCULATION OF SURPLUSES AVAILABLE FOR INTERREGIONAL SHIPMENT

(Quantities in hundredweights)

MILL LOCATION	(i) DAILY CAPACITY	(ii) POTENTIAL OUTPUT	(iii) IN SITU DEMAND	(iv) SURPLUS POTENTIAL OUTPUT: (ii) - (iii)	(v) SURPLUS AVAILABLE FOR INTERREGIONAL SHIPMENT[a]: (iv) x 67.9443%
Edmonton	1,500	375,000	490,280	--[b]	---
Calgary	7,850	1,962,500	373,144	1,589,356	1,079,878
Medicine Hat	11,100	2,775,000	97,177	2,677,823	1,819,429
Saskatoon	10,000	2,500,000	337,396	2,162,604	1,469,368
Winnipeg	19,120	4,780,000	543,475	4,236,525	2,878,479
Total	49,570	12,392,500	1,841,472	10,666,308[c]	7,247,154

[a] This is the surplus remaining at each mill location after Surplus Potential Output has been scaled down by a constant percentage factor. The effect of this reduction is to equate the total surplus of flour with the total deficit in flour.

[b] Edmonton is not able to supply all its own requirements and thus has no Surplus Potential Output.

[c] This figure is the sum of the mill location values and is not obtained from the deduction of Total In Situ Demand from Total Potential Output.

TABLE 5-3 - PROBLEM ONE: CALCULATION OF MARKET AREA DEFICITS

(Quantities in hundredweights)

MARKET AREA REFERENCE POINT	(i) DEMAND FOR FLOUR	(ii) DEMAND SUPPLIED IN SITU	(iii) DEFICIT: (i) - (ii)
Vancouver	922,514	---	922,514
Vancouver Export	1,355,094	---	1,355,094
Prince George	130,234	---	130,234
Revelstoke	202,482	---	202,482
Edmonton	490,280	375,000	115,280
Calgary	373,144	373,144	---
Medicine Hat	97,177	97,177	---
Saskatoon	337,396	337,396	---
Regina	280,226	---	280,226
Brandon	114,760	---	114,760
Winnipeg	543,475	543,475	---
Thunder Bay	4,126,564	---	4,126,564
Total	8,973,346	1,726,192	7,247,154

TABLE 5-4 - SOLUTION ONE

(Quantities in hundredweights)

MILL LOCATION	MARKET AREA				
	Vancouver	Vancouver Export	Prince George	Revelstoke	Edmonton
Calgary	747,162	---	130,234	202,482	---
Medicine Hat	175,352	1,355,094	---	---	---
Saskatoon	---	---	---	---	115,280
Winnipeg	---	---	---	---	---
TOTAL DEFICIT	922,514	1,355,094	130,234	202,482	115,280

MILL LOCATION	MARKET AREA			TOTAL INTERREGIONAL SHIPMENTS
	Regina	Brandon	Thunder Bay	
Calgary	---	---	---	1,079,878
Medicine Hat	280,226	---	8,757	1,819,429
Saskatoon	---	---	1,354,088	1,469,368
Winnipeg	---	114,760	2,763,719	2,878,479
TOTAL DEFICIT	280,226	114,760	4,126,564	7,247,154

Value of Objective Function = $25,366,405

TABLE 5-5 - PROBLEMS TWO, THREE AND FOUR: CALCULATION OF SURPLUSES AVAILABLE FOR INTERREGIONAL SHIPMENT

(Quantities in hundredweights)

MILL LOCATION	(i) DAILY CAPACITY	(ii) POTENTIAL OUTPUT	(iii) IN SITU DEMAND	(iv) SURPLUS POTENTIAL OUTPUT: (ii) - (iii)	(v) SURPLUS AVAILABLE FOR INTERREGIONAL SHIPMENT* : (iv) x r%
PROBLEM TWO					
Calgary	3,400	850,000	140,835	709,615	497,236
Medicine Hat	4,100	1,025,000	36,560	988,440	692,613
Winnipeg	11,120	2,780,000	204,467	2,575,533	1,804,705
Total	18,620	4,655,000	381,412	4,273,588	2,994,554
PROBLEM THREE					
Edmonton	1,500	375,000	162,894	212,106	147,409
Medicine Hat	7,000	1,750,000	32,287	1,717,713	1,193,762
Winnipeg	8,000	2,000,000	180,568	1,819,432	1,264,452
Total	16,500	4,125,000	375,749	3,749,251	2,605,623
PROBLEM FOUR					
Calgary	4,450	1,112,500	108,783	1,003,717	710,005
Saskatoon	10,000	2,500,000	98,361	2,401,639	1,698,859
Total	14,450	3,612,500	207,144	3,405,356	2,408,864

*See note at foot of Table 5-2. Values of r : in Problem Two, 70.0711; in Problem Three, 69.4971; and in Problem Four, 70.7375

TABLE 5-6 - PROBLEMS TWO, THREE AND FOUR: CALCULATION OF MARKET AREA DEFICITS

(Quantities in hundredweights)

MARKET AREA REFERENCE POINT	(i) DEMAND FOR FLOUR	(ii) DEMAND SUPPLIED IN SITU	(iii) DEFICIT: (i) - (ii)
PROBLEM TWO			
Vancouver	347,070	---	347,070
Vancouver Export	509,815	---	509,815
Prince George	48,997	---	48,997
Revelstoke	76,178	---	76,178
Edmonton	184,454	---	184,454
Calgary	140,385	140,385	---
Medicine Hat	36,560	36,560	---
Saskatoon	126,936	---	126,936
Regina	105,427	---	105,427
Brandon	43,175	---	43,175
Winnipeg	204,467	204,467	---
Thunder Bay	1,552,502	---	1,552,502
Total	3,375,966	381,412	2,994,554
PROBLEM THREE			
Vancouver	306,503	---	306,503
Vancouver Export	450,227	---	450,227
Prince George	43,270	---	43,270
Revelstoke	67,274	---	67,274
Edmonton	162,894	162,894	---
Calgary	123,976	---	123,976
Medicine Hat	32,287	32,287	---
Saskatoon	112,099	---	112,099
Regina	93,104	---	93,104
Brandon	38,129	---	38,129
Winnipeg	180,568	180,568	---
Thunder Bay	1,371,041	---	1,371,041
Total	2,981,372	375,749	2,605,623

TABLE 5-6 - Continued.

MARKET AREA REFERENCE POINT	(i) DEMAND FOR FLOUR	(ii) DEMAND SUPPLIED IN SITU	(iii) DEFICIT: (i) - (ii)
PROBLEM FOUR			
Vancouver	268,941	---	268,941
Vancouver Export	395,052	---	395,052
Prince George	37,967	---	37,967
Revelstoke	59,030	---	59,030
Edmonton	142,932	---	142,932
Calgary	108,783	108,783	---
Medicine Hat	28,330	---	28,330
Saskatoon	98,361	98,361	---
Regina	81,695	---	81,695
Brandon	33,456	---	33,456
Winnipeg	158,440	---	158,440
Thunder Bay	1,203,021	---	1,203,021
Total	2,616,008	207,144	2,408,864

TABLE 5-7 - SOLUTION TWO

(Quantities in hundredweights)

MILL LOCATION	MARKET AREA				
	Vancouver	Vancouver Export	Prince George	Revelstoke	Edmonton
Calgary	187,607	---	48,997	76,178	184,454
Medicine Hat	159,463	406,214	---	---	---
Winnipeg	---	103,601	---	---	---
TOTAL DEFICIT	347,070	509,815	48,997	76,178	184,454

MILL LOCATION	MARKET AREA				TOTAL INTERREGIONAL SHIPMENTS
	Saskatoon	Regina	Brandon	Thunder Bay	
Calgary	---	---	---	---	497,236
Medicine Hat	126,936	---	---	---	692,613
Winnipeg	---	105,427	43,175	1,552,502	1,804,705
TOTAL DEFICIT	126,936	105,427	43,175	1,552,502	2,994,554

Value of Objective Function = $10,482,689

TABLE 5-8 - SOLUTION THREE

(Quantities in hundredweights)

MILL LOCATION	MARKET AREA				
	Vancouver	Vancouver Export	Prince George	Revelstoke	Calgary
Edmonton	---	---	43,270	---	104,139
Medicine Hat	306,503	450,227	---	67,274	19,837
Winnipeg	---	---	---	---	---
TOTAL DEFICIT	306,503	450,227	43,270	67,274	123,976

MILL LOCATION	MARKET AREA				TOTAL INTERREGIONAL SHIPMENTS
	Saskatoon	Regina	Brandon	Thunder Bay	
Edmonton	---	---	---	---	147,409
Medicine Hat	112,099	93,104	---	144,718	1,193,762
Winnipeg	---	---	38,129	1,226,323	1,264,452
TOTAL DEFICIT	112,099	93,104	38,129	1,371,041	2,605,623

Value of Objective Function = $9,121,232

TABLE 5-9 - SOLUTION FOUR

(Quantities in hundredweights)

MILL LOCATION	MARKET AREA					
	Vancouver	Vancouver Export	Prince George	Revelstoke	Edmonton	Medicine Hat
Calgary	268,941	315,737	37,967	59,030	---	28,330
Saskatoon	---	79,315	---	---	142,932	---
TOTAL DEFICIT	268,941	395,052	37,967	59,030	142,932	28,330

MILL LOCATION	MARKET AREA				TOTAL INTERREGIONAL SHIPMENTS
	Regina	Brandon	Winnipeg	Thunder Bay	
Calgary	---	---	---	---	710,005
Saskatoon	81,695	33,456	158,440	1,203,021	1,698,859
TOTAL DEFICIT	81,695	33,456	158,440	1,203,021	2,408,864

Value of Objective Function = $8,506,967

TABLE 5-10 - PROBLEMS ONE, TWO, THREE AND FOUR : OPTIMAL SOLUTIONS TO DUAL PROBLEMS

(Cents per hundredweight)

	Problem One	Problem Two	Problem Three	Problem Four
F.o.b. mill prices				
Edmonton	-	-	12	-
Calgary	2	14	-	0
Medicine Hat	0	12	0	-
Saskatoon	3	-	-	0
Winnipeg	9	0	9	-
Delivered values				
Vancouver	374	386	374	372
Vancouver Export	348	360	348	348
Prince George	405	417	393	403
Revelstoke	377	389	384	375
Edmonton	353	367	--	350
Calgary	--	--	364	--
Medicine Hat	--	--	--	355
Saskatoon	--	370	358	--
Regina	363	365	363	363
Brandon	356	347	356	380
Winnipeg	--	--	--	360
Thunder Bay	349	340	349	346

Notes. - No mill was at this location in this Problem.
-- The demands of this market were supplied in situ, at zero cost, in this Problem.

TABLE 5-11 - SOLUTION FIVE (SUMMATION OF SOLUTIONS TWO, THREE AND FOUR)

(Quantities in hundredweights)

MILL LOCATION	M A R K E T A R E A						
	Vancouver	Vancouver Export	Prince George	Revelstoke	Edmonton	Calgary	Medicine Hat
Edmonton	---	---	43,270	---	---	104,139	---
Calgary	456,548	315,737	86,964	135,208	184,454	---	28,330
Medicine Hat	465,966	856,441	---	67,274	---	19,837	---
Saskatoon	---	79,315	---	---	142,932	---	---
Winnipeg	---	103,601	---	---	---	---	---
TOTAL DEFICIT	922,514	1,355,094	130,234	202,482	327,386	123,976	28,330

MILL LOCATION	M A R K E T A R E A					TOTAL INTERREGIONAL SHIPMENTS
	Saskatoon	Regina	Brandon	Winnipeg	Thunder Bay	
Edmonton	---	---	---	---	---	147,409
Calgary	---	---	---	---	---	1,207,241
Medicine Hat	239,035	93,104	---	---	144,718	1,886,375
Saskatoon	---	81,695	33,456	158,440	1,203,021	1,698,859
Winnipeg	---	105,427	81,304	---	2,778,825	3,069,157
TOTAL DEFICIT	239,035	280,226	114,760	158,440	4,126,564	8,009,041

Sum of values of Objective Functions = $28,110,888

TABLE 5-12 - COMPARATIVE COSTS OF SUPPLYING MARKET AREAS

(Costs expressed in dollars)

MARKET AREA	COST OF INTERREGIONAL SHIPMENT TO MARKET AREA	
	Solution One	Solution Five
Vancouver	3,435,259	3,441,071
Vancouver Export	4,715,727	4,728,159
Prince George	524,843	515,324
Revelstoke	759,308	765,362
Edmonton	403,480	1,151,385
Calgary	---	438,776
Medicine Hat	---	100,572
Saskatoon	---	855,745
Regina	1,017,220	1,019,329
Brandon	398,217	409,258
Winnipeg	---	570,384
Thunder Bay	14,112,351	14,115,523
ALL MARKET AREAS	25,366,405	28,110,888

TABLE 5-13 - NUMBER OF INTERREGIONAL FLOW PATHS ORIGINATING AT MILL LOCATIONS

MILL LOCATION	NUMBER OF FLOWS ORIGINATING AT MILL LOCATION	
	Solution One	Solution Five
Edmonton	0	2
Calgary	3	5
Medicine Hat	3	6
Saskatoon	2	6
Winnipeg	2	4
TOTAL	10	23

TABLE 5-14 - NUMBER OF INTERREGIONAL FLOW PATHS TERMINATING IN MARKET AREAS

MARKET AREA	NUMBER OF FLOWS TERMINATING IN MARKET AREA	
	Solution One	Solution Five
Vancouver and Vancouver Export	2	4
Prince George	1	2
Revelstoke	1	2
Edmonton	1	2
Calgary	0	2
Medicine Hat	0	1
Saskatoon	0	1
Regina	1	3
Brandon	1	2
Winnipeg	0	1
Thunder Bay	3	3
TOTAL	10	23

TABLE 5-15 - DISPOSITION OF FLOUR PRODUCED, BY MILL LOCATION

MILL LOCATION	SOLUTION ONE		SOLUTION FIVE	
	Hundredweight	Percent	Hundredweight	Percent
EDMONTON				
Total production	375,000	100.0	310,303	100.0
Quantity consumed in local region	375,000	100.0	162,894	52.5
Quantity shipped interregionally	---	---	147,409	47.5
CALGARY				
Total production	1,453,022	100.0	1,456,409	100.0
Quantity consumed in local region	373,144	25.7	249,168	17.1
Quantity shipped interregionally	1,079,878	74.3	1,207,241	82.9
MEDICINE HAT				
Total production	1,916,606	100.0	1,955,222	100.0
Quantity consumed in local region	97,177	5.1	68,847	3.5
Quantity shipped interregionally	1,819,429	94.9	1,886,375	96.5
SASKATOON				
Total production	1,806,764	100.0	1,797,220	100.0
Quantity consumed in local region	337,396	18.7	98,361	5.5
Quantity shipped interregionally	1,469,368	81.3	1,698,859	94.5
WINNIPEG				
Total production	3,421,954	100.0	3,454,192	100.0
Quantity consumed in local region	543,475	15.9	385,035	11.1
Quantity shipped interregionally	2,878,479	84.1	3,069,157	88.9
ALL MILL LOCATIONS				
Total production	8,973,346	100.0	8,973,346	100.0
Quantity consumed in local region	1,726,192	19.2	964,305	10.7
Quantity shipped interregionally	7,247,154	80.8	8,009,041	89.3

TABLE 5-16 - COMPARISON OF WEIGHTED AVERAGE LENGTHS OF FLOUR SHIPMENT PATHS

(Miles)

MILL LOCATION	WEIGHTED AVERAGE LENGTH OF ORIGINATING SHIPMENT PATHS	
	Solution One	Solution Five
Edmonton	---	281
Calgary	579	525
Medicine Hat	739	747
Saskatoon	845	767
Winnipeg	408	445
ALL MILL LOCATIONS	605	593

CHAPTER VI

CONCLUSION

The foci of attention in this study were the shipment patterns of wheat and flour in Canada. A general description of the basic directions of movement was first given through reference to the locations of the spatially separated nodes between which flows occur. Ways in which cognizance of corporate organization within the flour milling industry may assist in the explanation of flour shipment patterns were then suggested. Finally, in an application of linear programming, least cost flows of flour were derived for a set of western Canadian mills, under different assumptions of corporate ownership. Flows were generated for a situation in which the mills were under independent ownership, and for each of three companies individually supplying a constant share of the demand in each of the market areas delimited. The company flow patterns were then summed, and cost and flow pattern comparisons made with the optimal solution to the problem of shipment assignment in the independent mill ownership situation. It was concluded that distinct differences existed between the two patterns and that the variations could be interpreted as effects of actual corporate organization. Each multi-mill firm distributes flour from a set of mill locations different to those of the other multi-mill firms, and, in the pattern obtained from summation, all markets

are not only served from the mill location from which the combined cost of wheat purchase and flour shipment is lowest, but also from one or more other mill locations.

Qualifications must be added to the results of the least cost flow pattern analysis. A number of limitations have been recognized in Chapter One, one of the most important being that the transportation problem of each company was set up under the rigid assumption that the firm would supply a fixed and constant percentage of the demand existing in every market area. Company optima were consequently derived in a static context, and the summation of company patterns does not reflect competitive interrelationships between the firms. Other significant limitations are that production and consumption data had to be estimated from published sources, and that no account was taken of production costs in mills. As a result of these limitations, the results obtained in the present analysis are best regarded as suggestive of differences which may be found in a comparison of optimal and actual patterns, and which may be attributed to intra-industry corporate organization.

The onus on future research is to obtain more precise measurements of pattern differences and of the cost to the economy of the existence of the present as opposed to an alternative structure of corporate organization. Actual patterns are, however, the net result of the interplay be-

tween a complex of forces, all of which may not be considered in the derivation of an optimal pattern. For this reason care must be taken not to attach too much significance to a particular factor in explaining relatively small percentage deviations between optimal and actual patterns. In the present study, optimal patterns were compared, and the factors included in each derivation were the same.

Prior to more definite conclusions being drawn as to the utility of including corporate organizational factors in geographic analyses, further empirical investigation of the various categories of corporate organization is necessary. If it is subsequently found that explanation of spatial patterns can be enhanced through account being taken of corporate organizational factors, a rationale will exist for geographic analysis at the level of the firm. Conversely, if understanding is not improved, or if the effects on space of the multi-plant firm are no different to the combined effects of a number of single-plant firms, the case for specific analysis of the enterprise is weakened.

It has been shown in the present study that explanation of flows of flour in western Canada can be improved through account being taken of the locations of the mills owned by multi-mill firms. It also seems likely that similar assistance could be given to the explanation of flows of other commodities which are shipped to markets from

regional production or distribution points.

The way in which the multi-plant firm can distribute production among its plants may also be of spatial significance. The level of activity in a plant may directly contribute to the state of the local economy through the operation of the multiplier effect. Corporate policy as to spreading of production among plants can thus have an impact on the relative level of prosperity in an area.

Differences may exist between the single plant firm and the multi-plant firm in the manner in which location decisions are made. The entrepreneur who is entering an industry will have to take a number of location factors into account, including the location of rivals, but the multi-plant firm planning to establish a new plant may also have to consider the locations of its existing plants. This consideration may be especially important if the new plant will be shipping commodities to or from the older plants, or, if zonal delivered prices are in effect, when there is an incentive to supply all markets at the minimum cost.

BIBLIOGRAPHY

Alonso, W., "Location Theory," in J. Friedmann and W. Alonso (eds.), Regional Development and Planning: a Reader. M. I. T. Press, Cambridge, Mass., 1964, pp. 78-106.

Aylor, F. I., and Juillerat, M. E., Least-Cost Movement Analysis of Slaughter Cattle and Calves with Emphasis on the Southeast. Alabama Agricultural Experiment Station, Auburn, Ala., 1968, 127 pp.

Bain, J. S., Barriers to New Competition: Their Character and Consequences in Manufacturing Industries. Harvard University Press, Cambridge, Mass., 1962, 329 pp.

Barr, B. M., The Soviet Wood-Processing Industry: a Linear Programming Analysis of the Role of Transportation Costs in Location and Flow Patterns. University of Toronto Department of Geography Research Publication No. 5. University of Toronto Press, Toronto, 1970, 135 pp.

Canada. Agricultural Economics Research Council of Canada. The Benefits and Burdens of Feedgrain Transportation Policy, by M. L. Lerohl, G. A. MacEachern and H. Vandermeulen. Ottawa, 1970, 164 pp.

_____. The Transportation of Feed Grains in Eastern Canada: An Analysis of Rates, Routes and Costs, by H. V. Walker. Publication No. 8, 1967, 85 pp.

Canada. Department of Agriculture, Board of Grain Commissioners for Canada. Grain Elevators in Canada for Crop Year 1969-70 As at August 1, 1969. The Queen's Printer, Ottawa, 1969, 217 pp.

_____. Protein Content of Canadian Wheat 1927-1968, by V. Martens and I. Hlynka. Winnipeg, 1969, 137 pp.

Canada. Dominion Bureau of Statistics. Apparent Per Capita Domestic Disappearance of Food. Catalogue No. 32-226. The Queen's Printer, Ottawa, annual.

_____. Estimated Population of Canada by Province at June 1, 1970. Catalogue No. 91-201. The Queen's Printer, Ottawa.

_____. The Flour and Feed Milling Industries. Catalogue No. 32-215, The King's Printer, Ottawa, annual, 1948-1952.

_____. The Flour Milling Industry. Catalogue No. 32-215. The Queen's Printer, Ottawa, annual, 1953-1959.

_____. Flour Mills. Catalogue No. 32-215. The Queen's Printer, Ottawa, annual, 1960-1968.

_____. Grain Milling Statistics. Catalogue No. 32-003. The Queen's Printer, Ottawa, monthly, December 1966 - December 1967.

_____. Grain Trade of Canada. Catalogue No. 22-201. The Queen's Printer, Ottawa, annual, 1966-67 and 1967-68.

_____. Population Estimates for Counties and Census Divisions, 1967. Catalogue No. 91-206. The Queen's Printer, Ottawa.

_____. Quarterly Bulletin of Agricultural Statistics. Catalogue No. 21-003. The Queen's Printer, Ottawa, quarterly, October-December 1965 - October-December 1969.

_____. Railway Freight Traffic, Year Ended December 31, 1967. Catalogue No. 52-205. The Queen's Printer, Ottawa,

_____. Report on the Flour and Feed Milling Industries in Canada. The King's Printer, Ottawa, annual, 1946-1947.

_____. Shipping Report, Part Two: International Seaborne Shipping (by Port). Catalogue No. 54-203. The Queen's Printer, Ottawa, 1967.

_____. Shipping Report, Part Three: Coastwise Shipping. Catalogue No. 54-204. The Queen's Printer, Ottawa, 1967.

_____. Trade of Canada: Exports by Mode of Transport. Catalogue No. 65-206. The Queen's Printer, Ottawa, 1967.

_____. Trade of Canada, Volume Two: Exports. Catalogue No. 65-202. The Queen's Printer, Ottawa, annual, 1946-1958, biennial 1959-60 - 1965-66, triennial 1966-1968.

Canada. Economic Council of Canada. Interregional Competition in Canadian Cereal Production, by W. J. Craddock. Special Study No. 12. Ottawa, 1970, 257 pp.

Chamberlin, E. H., The Theory of Monopolistic Competition. Eighth edition, Harvard University Press, Cambridge, Mass., 1965, 396 pp.

Cox, K. R., "The Application of Linear Programming to Geographic Problems". Tijdschrift voor Economische en Sociale Geografie, Vol. 56, 1965, pp. 228-236.

Devletoglou, N. E., "A Dissenting View of Duopoly and Spatial Competition". Economica, Vol. 32, 1965, pp. 140-160.

Dorfman, R., Samuelson, P., and Solow, R. M., Linear Programming and Economic Analysis. McGraw-Hill Book Company, Inc., New York, 1958, 525 pp.

Fetter, F. A., "The Economic Law of Market Areas". Quarterly Journal of Economics, Vol. 38, 1923-1924, pp. 520-529

"Flour Consumption in Canada". The Northwestern Miller, Vol. 281, January 1971, p. 17.

Garrison, W. L., "Spatial Structure of the Economy: Part Two". Annals, Association of American Geographers, Vol. 49, 1959, pp. 471-482.

Greenhut, M. L., Plant Location in Theory and in Practise: The Economics of Space. University of North Carolina Press, Chapel Hill, North Carolina, 1956, 338 pp.

Hoover, E. M., The Location of Economic Activity. McGraw-Hill Book Company, Inc., New York, 1948, 310 pp.

Hotelling, H., "Stability in Competition". The Economic Journal, Vol. 39, 1929, pp. 41-57.

Isard, W., Location and Space Economy: a General Theory Relating to Industrial Location, Market Areas, Land Use, Trade and Urban Structure. The Technology Press of M. I. T. and John Wiley and Sons, Inc., New York, 1956, 350 pp.

Koch, A. R., and Snodgrass, M. M., "Linear Programming Applied to Location and Product Flow Determination in the Tomato Processing Industry". Papers and Proceedings of the Regional Science Association, Vol. 5, 1959, pp. 151-162.

Krumme, G., "Toward a Geography of Enterprise". Economic Geography, Vol. 45, 1969, pp. 30-40.

Leath, M. N., and Martin, J. E., "The Transhipment Problem with Inequality Restraints". Journal of Farm Economics, Vol. 48, 1966, pp. 894-908.

Lerner, A. P., and Singer, H. W., "Some Notes on Duopoly and Spatial Competition". Journal of Political Economy, Vol. 45, 1937, pp. 145-186.

"List of Flour Mills in the United States and Canada: Canada". The Northwestern Miller, Vol. 274, September 1967, pp. 75-80; Vol. 276, September 1969, pp. 72-80.

Markwalder, D. W., "The Flour Milling Industry: An Economic Study of Excess Capacity, Part Ten." The Northwestern Miller, Vol. 265, July 24, 1961, pp. 28-32.

Maxfield, D. W., "An Interpretation of the Primal and Dual Solutions of Linear Programming". The Professional Geographer, Vol. 21, 1969, pp. 255-263.

Morrill, R. L., "The Movement of Persons and the Transportation Problem", in W. L. Garrison and D. F. Marble (eds.), Quantitative Geography, Part One: Economic and Cultural Topics. Northwestern University Studies in Geography No. 13. Northwestern University, Evanston, Ill., 1967, pp. 84-93.

_____, and Garrison, W. L., "Projections of Interregional Patterns of Trade in Wheat and Flour." Economic Geography, Vol. 36, 1960, pp. 116-126.

Polopolus, L., "Optimum Plant Numbers and Locations for Multiple Product Processing". Journal of Farm Economics, Vol. 47, 1965, pp. 287-295.

Smithies, A., "Optimum Location in Spatial Competition". Journal of Political Economy, Vol. 49, 1941, pp. 423-439.

Steed, G. P. F., "Corporate Enterprise and the Location Decision Process", in W. R. D. Sewell and H. D. Foster (eds.), The Geographer and Society. Western Geographical Series Vol. 1. University of Victoria Department of Geography, 1970, pp. 160-171.

_____, "Locational Implications of Corporate Organization of Industry". The Canadian Geographer, Vol. 15, 1971, pp. 54-57.

Stevens, B. H., "An Application of Game Theory to a Problem in Locational Strategy". Papers and Proceedings of the Regional Science Association, Vol. 7, 1961, pp. 143-157.

Stollsteimer, J. F., "A Working Model for Plant Numbers and Locations". Journal of Farm Economics, Vol. 45, 1963, pp. 631-645.

Teitz, M. B., "Locational Strategies for Competitive Systems" Journal of Regional Science, Vol. 8, 1968, pp. 135-148.

United States. Department of Agriculture, Economic Research Service. Regional and Sectoral Analysis of the Wheat-Flour Economy, by B. H. Wright. Marketing Research Report No. 858. Washington, D.C., 1969, 46 pp.

Wheat Flour Institute, From Wheat to Flour. Wheat Flour Institute, Chicago, 1966, 76 pp.

Yackulic, G., "Flour Milling Prosperity in Peril". Western Business and Industry, Vol. 38, November 1964, pp. 26-28.

Yeates, M., "Hinterland Delimitation: a Distance Minimizing Approach". The Professional Geographer, Vol. 15, November 1963, pp. 7-10.

APPENDIX

CALCULATION OF APPARENT PER CAPITA CONSUMPTION OF HARD WHEAT FLOUR IN STUDY AREA IN 1967

(British Columbia, the Prairie Provinces & Northern Ontario)

		Hundredweights
(1)	Western Canadian flour mill inventory as at Dec. 31, 1966[a]	572,000
(2)	Western Canadian flour production in 1967[b]	14,696,000
(3)	Total (1) + (2)	15,268,000
(4)	Shipments to Eastern Canada & exports[c]	9,176,018
(5)	Total (3) - (4)	6,091,982
(6)	Western Canadian flour mill inventory as at Dec. 31, 1967[d]	467,000
(7)	Total (5) - (6) : apparent domestic disappearance	5,624,982
(8)	Apparent per capita domestic disappearance:	
	(7) ÷ 5,583,491 (combined population of British Columbia, the Prairie Provinces and the Ontario Census Divisions of Kenora, Rainy River and Thunder Bay)[e]	1.0

Data sources: [a] Canada. Dominion Bureau of Statistics. Grain Milling Statistics, Cat. No. 32-003. The Queen's Printer, Ottawa, Dec. 1966, p. 2.

[b] Ibid., monthly issues for Jan. 1967 to Dec. 1967 inclusive, p. 2.

[c] Idem, Railway Freight Traffic, Year Ended Dec. 31, 1967. Cat. No. 52-205. The Queen's Printer, Ottawa, Table 15, p. 88; Idem, Shipping Report, Part Two: International Seaborne Shipping (by Port), 1967. Cat. No. 54-203. The Queen's Printer, Ottawa, Table 6, pp. 34, 39-48;

Idem, Shipping Report, Part Three: Coastwise Shipping, 1967. Cat. No. 54-204. The Queen's Printer, Ottawa, Table 11, pp. 56, 63; Idem, Trade of Canada, Volume Two: Exports, Calendar Years 1966-1968. Cat. No. 65-202. The Queen's Printer, Ottawa, Table 3, p. 86; Idem, Trade of Canada: Exports by Mode of Transport, 1967. Cat. No. 65-206. The Queen's Printer, Ottawa, Table 5, pp. 171-172.

[d]Idem, Grain Milling Statistics. Cat. No. 32-003. The Queen's Printer, Ottawa, December 1967, p. 2.

[e]Idem, Population Estimates for Counties and Census Divisions, 1967. Cat. No. 91-206. The Queen's Printer, Ottawa, Table 6, pp. 29-31.